USER MANUAL

COMPex*Pro*™ Series

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CONTENTS

1 INTRODUCTION

2 FUNDAMENTALS

3 SAFETY

4 SPECIFICATIONS, REQUIREMENTS AND ACCESSORIES

5 INSTALLATION

6 OPERATION

7 MAINTENANCE

8 CONTROL SOFTWARE

9 TROUBLESHOOTING

10 GLOSSARY

LIST OF FIGURES

INDEX

TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 About this Manual 1

1.1.1 Intended Audience 1

1.1.2 Numbering of Chapters, Pages and Instructions . 2

1.1.3 Typographic Conventions. 2

1.1.4 Trademarks 3

1.2 Safety 3

1.2.1 Laser Safety Classification 3

1.2.2 Safety Information 4

1.2.3 Signal Words and Symbols 4

1.2.3.1 Signal Words. 4

1.2.3.2 Symbols. 5

1.3 Laser Terminology According to ISO 11145. 6

1.4 Conversion Tables 7

1.4.1 Measurements 7

1.4.2 Temperatures. 7

1.4.3 Calcium Hardness 8

1.5 Feedback Regarding Documentation 8

2 FUNDAMENTALS 9

2.1 The Excimer Laser Device 9

2.2 Functional Description of the Laser 10

2.3 System Overview. 12

2.3.1 Designation of Sides 12

2.3.2 Exterior Views 13

2.3.3 Inside View (Except COMPex*Pro* F2) 15

2.3.4 Optional Halogen Source 16

A0510COMPPRO

2.4 Primary System Components 16
2.4.1 Laser Tube 16
2.4.2 Resonator Optics 18
2.4.3 Energy Monitor 18
2.4.4 High Voltage Circuit 19
2.4.4.1 HV Power Supply 20
2.4.4.2 Thyratron 20
2.4.5 Laser Control 21
2.4.6 Electrical System 22
2.4.7 Gas Supply / Exhaust System 23
2.4.8 Cooling System 27
2.4.9 Purge Gas System 28
2.5 Monitoring and Fail-Safety Systems 29
2.5.1 Watchdogs 29
2.5.2 Data Ring Selftest 29
2.5.3 Interlocks 29
2.5.4 External Interlock and Laser Warning Lamp . . . 30
2.6 Pulse Triggering Modes 30
2.7 Energy Management 31
2.7.1 Fundamental Running Modes 31
2.7.2 Constant Energy Operation With Gas Actions . . 32
2.7.2.1 Halogen Injections 32
2.7.2.2 Partial Gas Replacements 33
2.7.2.3 HI/PGR Algorithm 34
2.7.3 Constant Energy Operation Without Gas Actions 36
2.8 Operating Modes 37
2.8.1 OFF Mode 37
2.8.2 OFF, WAIT Mode 38
2.8.3 ON Mode 38
2.8.4 NEW FILL Mode 38
2.9 Laser Operation 38

A0510COMPPRO

3 SAFETY 39

3.1 General Safety Aspects 39

3.1.1 Applicable Standards 39

3.1.2 Basic Operation and Designated Use 40

3.1.3 Organizational Measures 41

3.1.4 Selection and Qualification of Personnel - Basic Responsibilities 42

3.1.5 Safety Instructions Governing Specific Operational Phases 42

3.2 Specific Safety Aspects 44

3.2.1 Physical Hazards 45

3.2.1.1 Laser Radiation Safety 45

3.2.1.2 High Voltage / Electric Energy. 46

3.2.1.3 Halogen Gases 47

3.2.1.4 Ozone 48

3.2.2 Personnel Safety 49

3.2.2.1 Laser Radiation Safety 49

3.2.2.2 Electrical Safety. 52

3.2.2.3 Gas Safety. 53

3.2.2.4 Pressure Vessel Safety 55

3.2.2.5 Seismic Protection. 55

3.2.3 Constructive Safety Features 56

3.2.3.1 Radiation Safety Features. 56

3.2.3.2 Electrical Safety Features 58

3.2.3.3 Pressure and Gas Handling Safety Features . 59

3.2.3.4 Fire Safety Features 59

3.2.3.5 Mechanical Safety Features 60

3.2.3.6 General Safety Features 60

3.3 Labels 61

3.3.1 Labels on Outside of Laser Device 62

3.3.1.1 Beam Exit Side 62

3.3.1.2 Connection Side 64

3.3.2 Labels Inside Laser Device 67

A0510COMPPRO

4 SPECIFICATIONS, REQUIREMENTS AND ACCESSORIES 71

4.1 Laser Specifications 71

4.1.1 COMPex*Pro* 100 Series 72

4.1.2 COMPex*Pro* 200 Series 73

4.1.3 COMPex*Pro* F2 Series 74

4.2 Facilities 75

4.2.1 Environmental Conditions 75

4.2.1.1 Transport and Storage 75

4.2.1.2 Operation. 75

4.2.2 Gases 76

4.2.2.1 Single Gases 78

4.2.2.2 Gas Mixtures 80

4.2.3 Power Supply 81

4.2.4 Cooling Water. 82

4.2.5 Air Intake / Exhaust 83

4.3 Connections and Space Requirements. 84

4.3.1 Dimensions and Weight 84

4.3.2 Beam Exit Position 87

4.3.3 Foot Configuration 88

4.3.4 Gas Connections 89

4.3.4.1 Pressure Regulators 91

4.3.4.2 Gas Cabinets. 91

4.3.5 Electrical Connection 92

4.3.6 Cooling Water Connections 93

4.3.7 Air Intake and Exhaust Connections 94

4.3.8 Control Lines 95

4.3.8.1 Serial Interface 95

4.3.8.2 Remote Socket 95

4.3.8.3 Trigger Signal Ports. 96

4.3.8.4 Sync. Out Signal 97

4.3.9 Maintenance Area 98

4.4 Accessories 99

4.4.1 Vacuum Pump 99

4.4.2 Halogen Filter 99

A0510COMPPRO

5 INSTALLATION 101

5.1 Transport and Unpacking 101

5.1.1 Safety 101

5.1.2 Transport and Storage Conditions 102

5.1.3 Floor Loads 103

5.1.3.1 Packaging Dimensions and Weight. 103

5.1.4 Transport Packaging 104

5.1.5 Transport and Unpacking Procedure 105

5.1.6 Transport / Lifting with Rigid Packaging 106

5.1.7 Incoming Goods Inspection 106

5.1.8 Remove Rigid Packaging 107

5.1.9 Transport / Lifting without Rigid Packaging . . . 109

5.1.10 Remove Anti-Static Inner Cover 110

5.2 Installation 111

5.2.1 Installation Procedure. 111

5.2.2 Position Laser Device. 112

5.2.3 Visual Check 113

5.2.4 Transport Locks 113

5.2.5 Connect Remote Socket 114

5.2.6 Connect Mains Power Supply Lines. 115

5.2.7 Connect Exhaust Lines 117

5.2.7.1 Connect Laser Device Housing Exhaust Line 117

5.2.7.2 Connect Laser Tube Exhaust Line (Including Vacuum Pump) 119

5.2.8 Connect Gas Lines. 122

5.2.9 Connect Water Lines (COMPex*Pro* 110, COMPex*Pro* 205, COMPex*Pro* F_2) 125

5.2.10 Connect Signal Lines 128

5.2.10.1 Connect the Handheld Keypad 128

5.2.10.2 Connect a Remote PC 130

5.2.11 Leak Test and Passivate Laser Gas Lines. . . . 130

5.2.12 Leak Test Laser Tube 134

5.2.13 Fill Laser Tube (New Fill) 135

6 OPERATION 137

6.1 Operating and Display Elements 138

6.1.1 Operating Panel 138

6.1.1.1 Main Switch 138
6.1.1.2 Power ON Lamp 139
6.1.1.3 Key Switch 139
6.1.1.4 Control Voltage Lamp 139

6.1.2 Laser Radiation Warning Lamp 140

6.1.3 Handheld Keypad 140

6.1.3.1 Display 142
6.1.3.2 Numerical Input Keys 143
6.1.3.3 Cursor Keys 143
6.1.3.4 ENTER Key 143
6.1.3.5 EXE Key 143
6.1.3.6 BREAK Key 143
6.1.3.7 RUN STOP Key 144
6.1.3.8 TRIGGER INT EXT Key 144
6.1.3.9 MODE Key 145
6.1.3.10 REPRATE / HV / EGY Keys 145
6.1.3.11 COUNTS Keys 146
6.1.3.12 MENU Keys 146
6.1.3.13 EGY CAL Key 146
6.1.3.14 Function Keys 147
6.1.3.15 GAS Keys 148

6.2 Routine Operating Sequences 148

6.2.1 Check Beam Path 149

6.2.2 Turn On Gases 150

6.2.3 Start-Up Laser Device 153

6.2.4 Start Laser Operation 155

6.2.5 Stop Laser Operation 157

6.2.6 Shut-Down Laser Device 158

6.2.7 Turn Off Gases 159

A0510COMPPRO

6.3 Operating Modes and Parameters 160
6.3.1 Change Trigger Mode 160
6.3.2 Change Repetition Rate 161
6.3.3 Change Running Mode 162
6.3.4 Change Beam Output Energy Value 163
6.3.5 Change Charging Voltage 164
6.4 Set-Up and Service 165
6.4.1 Select Charge On Demand (COD) 165
6.4.2 Select and Change Gas Menu 166
6.4.3 Reset Gas Menu to Factory Settings 167
6.4.4 Select Gas Mode 168
6.4.5 Activate Temperature Control (Optional) 168
6.4.6 Read Total Counter 169
6.4.7 Read User Counter 170
6.4.8 Reset User Counter 170
6.4.9 Emergency Fill with Inert Gas 171

7 MAINTENANCE 173

7.1 Laser Logbook 173
7.2 Maintenance Schedule 174
7.2.1 COMPex*Pro* 100 / COMPex*Pro* 200 174
7.2.2 COMPex*Pro* F_2 175
7.3 Lockout / Tagout 176
7.4 Gas System Maintenance 179
7.4.1 Flush Gas Line 179
7.4.2 Purge Gas Line 180
7.4.3 Exchange Halogen Gas Cylinder 182
7.4.4 Exchange Rare, Buffer or Inert Gas Cylinder . . 187
7.5 Laser Tube Maintenance 192
7.5.1 New Fill 192
7.5.2 Manual Halogen Injection 195
7.5.3 Purge Laser Tube 196
7.5.4 Re-Passivate Laser Tube 198

A0510COMPPRO

7.6 Tube Optics Maintenance 200

7.6.1 Exchange Pre-Mounted Tube Optics (COMPex*Pro* 100 / COMPex*Pro* 200) 201

7.6.2 Disassemble / Assemble Tube Optics Mounts (COMPex*Pro* 100 / COMPex*Pro* 200) 208

7.6.3 Clean Tube Optics (COMPex*Pro* 100 / COMPex*Pro* 200) 211

7.6.4 Exchange Pre-Mounted Tube Optics (COMPex*Pro* F_2) 214

7.6.5 Disassemble / Assemble Tube Optics Mounts (COMPex*Pro* F_2) 221

7.7 Energy Monitor Maintenance 223

7.7.1 Calibrate Energy Monitor 223

7.7.2 Clean Beam Splitter 226

7.7.2.1 COMPex*Pro* 100 / COMPex*Pro* 200 227

7.7.2.2 COMPex*Pro* F_2 228

7.7.3 Exchange Energy Monitor Attenuators 230

7.7.3.1 COMPex*Pro* 100 / COMPex*Pro* 200 230

7.7.3.2 COMPex*Pro* F_2 231

7.8 Laser Resonator Alignment 232

7.9 Installation and Alignment of Unstable Resonator Optics (Option) 236

7.10 Thyratron Maintenance 242

7.11 Halogen Filter Maintenance 245

7.11.1 Check Halogen Filter Filling Ratio 246

7.11.2 Exchange Halogen Filter Cartridge 246

7.12 Preparation for Transport / Storage 250

7.12.1 Transportation Fill 250

7.12.2 Disconnect Gas Lines 251

8 CONTROL SOFTWARE 255

8.1 Communication Syntax 256

8.2 Operating Modes 258

8.2.1 Overview of Operating Modes 258

A0510COMPPRO

8.2.2 Operating Mode Setting Restrictions 259
8.2.3 Description of Operating Modes 260
8.2.3.1 OFF 260
8.2.3.2 ON 261
8.2.3.3 SKIP 262
8.2.3.4 NEW FILL 262
8.2.3.5 PASSIVATION FILL 263
8.2.3.6 PURGE RESERVOIR 263
8.2.3.7 SAFETY FILL 264
8.2.3.8 TRANSPORT FILL 264
8.2.3.9 FLUSHING 265
8.2.3.10 CONT 265
8.2.3.11 HI 266
8.2.3.12 PGR 266
8.2.3.13 MANUAL FILL INERT 266
8.2.3.14 FLUSH <XY> LINE 267
8.2.3.15 PURGE <XY> LINE 267
8.2.3.16 CAPACITY RESET 268
8.2.3.17 LL OFF 268
8.2.3.18 ENERGY CAL 268
8.2.4 Status Codes 270
8.3 Laser Parameter Commands 272
8.3.1 Overview of Laser Parameters 272
8.3.2 Operating Mode Setting Restrictions 274
8.3.3 Parameter Polling Restrictions 274
8.3.4 Running Modes and Operating Parameters . . . 275
8.3.4.1 MODE 275
8.3.4.2 EGY and EGY SET 275
8.3.4.3 EGY RANGE 276
8.3.4.4 HV 277
8.3.4.5 TRIGGER 277
8.3.4.6 REPRATE 278
8.3.4.7 COUNTS 279
8.3.5 Gas System and Gas Supply 279
8.3.5.1 GAS MODE 279
8.3.5.2 HALOGEN, RARE, BUFFER and INERT . . . 280
8.3.5.3 MENU 281

A0510COMPPRO

8.3.6 Pulse and Time Counters 282
8.3.6.1 TOTALCOUNTER 282
8.3.6.2 COUNTER 282
8.3.6.3 TIMEOUT 283
8.3.7 System Status and Maintenance 284
8.3.7.1 COD 284
8.3.7.2 FILTER 285
8.3.7.3 FILTER CONTAMINATION 285
8.3.7.4 INTERLOCK 286
8.3.7.5 POWER STABILIZATION ACHIEVED 286
8.3.7.6 PRESSURE 287
8.3.7.7 PULSE DIFF 287
8.3.7.8 RESERVOIR TEMP 288
8.3.7.9 TEMP CONTROL 288
8.3.8 Halogen Source 289
8.3.8.1 ACCU 289
8.3.8.2 CAP.SET and CAP.LEFT 289
8.3.8.3 LEAKRATE 290
8.3.8.4 TEMP 290
8.3.8.5 ROOMTEMP 291
8.3.9 General Information 291
8.3.9.1 TYPE OF LASER 291
8.3.9.2 VERSION 291

9 TROUBLESHOOTING 293

9.1 Warnings and Error Messages 294
9.1.1 Duty Cycle Exceeded (ON:03) 295
9.1.2 Energy Cal. Error (OFF:7) 295
9.1.3 Error Temperature Measurement (OFF:12) . . . 296
9.1.4 Fatal Error, COM-Datalink (-) 296
9.1.5 Fatal Error, LWL-Datalink (OFF:5) 296
9.1.6 Fatal Error, Watchdog (OFF:4) 299
9.1.7 Fluorine Valve Not Opened (OFF:13; ON:13) . 299
9.1.8 Halogen Pressure Too High (OFF:33) 299
9.1.9 HI in Prep (ON:34) 299
9.1.10 Inert Valve Closed (OFF:39) 300
9.1.11 Interlock XXX (OFF:1) 300

A0510COMPPRO

9.1.12 Leak!-Check Windows (FLUSHING LEAKTEST CONT:30) 300
9.1.13 Low Light (OFF:26) 301
9.1.14 Low Pressure (OFF:10; ON:10) 301
9.1.15 New Gas Fill Needed (OFF:8; ON:8) 301
9.1.16 No Capacity Left (OFF:11) 302
9.1.17 No Gas Flow (XX:3) 302
9.1.18 No Vacuum (OFF:9) 303
9.1.19 No Vacuum (ON:9) 304
9.1.20 Not Available (OFF:35) 304
9.1.21 OFF:41 (OFF:41) 304
9.1.22 ON:40 (ON:40) 304
9.1.23 ON:41 (ON:41) 305
9.1.24 Polling (OFF:6) 305
9.1.25 Preset Energy too High (OFF:2; ON:2) 305
9.1.26 RAM Check Error (OFF:29) 306
9.1.27 Timeout (OFF:31) 306
9.1.28 Warm-up 8min (OFF:21) 307
9.1.29 Warning! Repetition Rate for COD 50 Hz (ON:37) 307
9.1.30 Wrong Pressure (OFF:27) 307
9.2 Interlocks 308
9.2.1 Overload 309
9.2.2 Remote 309
9.2.3 Temp.Res. 310
9.2.4 Ventilation 310
9.3 Self-Firing 311
9.4 No Trigger Signal 311
9.5 Corrosion in Gas System 312
9.6 Laser Device Does Not Start 313
9.7 Beam Energy Too Low 314
9.8 Low Light 319
9.9 Fuses 324
9.9.1 Fuses Inside Laser Device 324
9.9.2 Fuses Outside Laser Device 325

A0510COMPPRO

10 GLOSSARY 327

LIST OF FIGURES 337

INDEX 341

A0510COMPPRO

1 INTRODUCTION

This chapter describes the contents of this manual as well as the conventions, safety information and units used in this manual.

1.1 About this Manual

This instruction manual is intended to familiarize the user with the COMPex*Pro*™ Series excimer laser device and its designated use.

The instruction manual contains important information on how to operate and routinely maintain the COMPex*Pro* laser device safely, properly and most efficiently. Observing these instructions helps to avoid danger, reduce repair costs and downtimes and increase the reliability and lifetime of the COMPex*Pro*.

The instruction manual must always be available wherever the COMPex*Pro* is in use.

The instruction manual must be read and applied by any person in charge of carrying out work with and on the COMPex*Pro*, such as:

– operation including setting up, troubleshooting in the course of work, removal of production waste, care and disposal of consumables,

– service (maintenance, inspection, repair) and/or

– transport.

The instruction manual is to be supplemented by the respective national rules and regulations for accident prevention and environmental protection.

1.1.1 Intended Audience

This manual is intended for:

– Operators, who have completed the Basic Operations course for COMPex*Pro* laser devices. We define an operator as someone who operates the COMPex*Pro* in normal day-to-day operations.

– Process engineers, who have completed the Advanced Operations course for COMPex*Pro* laser devices. We define a process engineer as someone who prepares jobs for production and other purposes and monitors production quantity and quality.

– Any reader who wishes to acquire general knowledge of the COMPex*Pro* laser device.

1.1.2 Numbering of Chapters, Pages and Instructions

The pages of this manual are numbered continuously. The page number appears in the lower outside corner of every page.

The chapters are numbered continuously. The name of the chapter appears in the upper outside corner of every even page.

Each chapter ends with an even page number. Consequently, certain even pages at the ends of chapters will be intentionally left blank.

Each step within a procedure is sequentially numbered.

1.1.3 Typographic Conventions

Menu commands, enquiries and prompts are written in uppercase letters enclosed by quotation marks.

– Example: “ARE YOU SURE (Y/N) ?”

Single keys to be pressed are written in angled brackets.

– Example: Press <Y> to confirm and continue.

The key description <ENTER> is used to describe the key marked or referred to as ENTER, ↵, RETURN, CR or CARRIAGE RETURN.

A plus sign between two keys means that the two keys are to be pressed simultaneously.

– Example: Press <CTRL> + <Q> to select “QUIT”.

Commands to be typed into the keyboard are written in non-proportional lower-case letters.

– Example: Type `cd lambda`.

Programming commands of the remote software to be used literally are written in upper-case letters.

– Example: OPMODE=

Descriptions in commands or messages that are not to be used literally are written in italic letters.

– Example: OPMODE=*operating mode*
  A permitted command is to be used instead of the words operating mode.

Examples are written in non-proportional, upper-case letters to simulate the appearance of computer monitor displays or printer output.

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1.1.4 Trademarks

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1.2 Safety

1.2.1 Laser Safety Classification

Lasers and laser systems are classified according to their relative hazards. These classifications are found in the American National Standards for the Safe Use of Lasers (ANSI Z 136.1-2000), FDA 21 CFR 1040.10 and 1040.11 and IEC-825.
Within this classification, the COMPex*Pro* excimer laser is a class IV (high power) laser. It must be regarded as a potential hazard to the human operator. When connected to a correspondingly configured beam guidance system, the COMPex*Pro* becomes a class I laser device.
The laser beam must also be regarded as a potential fire hazard.

A0510COMPPRO

1.2.2 Safety Information

Chapter 3 (Safety) describes the physical hazards related to the laser device, the means of protection against these hazards and the safety features incorporated in the design of the laser device.

The Safety chapter must be read by all persons entrusted with any sort of work on the COMPex*Pro* laser device.

Never start to follow the procedures detailed in this manual unless you have read and fully understood the information given in the Safety chapter.

1.2.3 Signal Words and Symbols

The COMPex*Pro* documentation may contain sections in which particular hazards are defined or special attention is drawn to particular conditions. These sections are indicated with signal words in accordance with ANSI Z-535.2-1991 and safety symbols (pictorial hazard alerts) in accordance with ANSI Z535.3-1991.

1.2.3.1 Signal Words

Four signal words are used in the COMPex*Pro* documentation: DANGER, WARNING, CAUTION and NOTE.

The signal words DANGER**,** WARNING and CAUTION designate the degree or level of hazard:

DANGER
Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING
Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION
Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It is also used to alert against unsafe practices that may result in property damage.

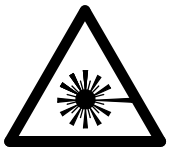
Use of the signal word "***NOTE"***:

NOTE
Used to define sections, where particular attention should be paid to ensure efficient operation or servicing of the laser device.

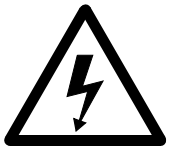
A0510COMPPRO

1.2.3.2 Symbols

The signal words **DANGER**, **WARNING**, and **CAUTION** are always emphasized with a safety symbol that indicates a special hazard, regardless of the hazard level:



This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by **laser radiation**.



This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by **electricity**.

This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by **hot surface(s)**.

This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by **flammable substances**.

This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by **toxic substances**.

This symbol is combined with one of the signal words **DANGER**, **WARNING** or **CAUTION** to indicate a hazardous situation caused by circumstances other than those described above.

A0510COMPPRO

1.3 Laser Terminology According to ISO 11145

ISO 11145 (“Optics and Optical Instruments - Lasers and Laser Related Equipment - Vocabulary and Symbols”) contains a list of laser terminology.

To prevent misunderstandings, this manual strictly differentiates between “laser” and “laser device” (see Figure 1). Thus “start laser device” means that the power is off and shall be turned on. To “start the laser” means to switch on the laser beam and start lasing..

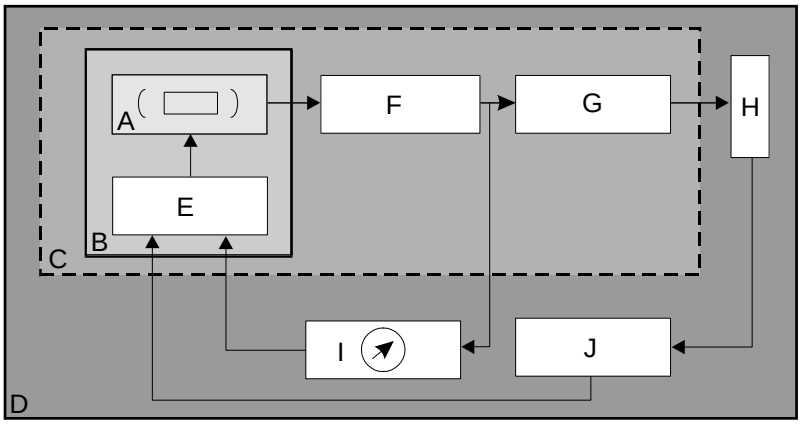


Figure 1: *Laser components according to ISO 11145*

Definitions:

A Laser
Consists of an amplifying medium capable of emitting coherent radiation with wavelengths up to 1 mm by means of stimulated emission.

B Laser Device
A laser (A), where the radiation is generated, together with essential additional facilities (E) that are necessary to operate the laser (e.g. cooling, power and gas supply) .

C Laser Assembly
Laser device (B) together with specific, normally optical, mechanical and/or electrical system components for beam handling and forming (F: e.g. mirrors, lenses; G: e.g. telescope, focussing).

D Laser Unit
One ore more laser assemblies (C) together with measurement and control systems (I) and handling systems (J: robotics, workpiece positioning).

H Workpiece

A0510COMPPRO

1.4 Conversion Tables

1.4.1 Measurements

Listed below are the units of measure used in this manual and their equivalents according to the SI standard:

1 meter (m)	=	39.37 inches (in)
1 meter (m)	=	3.28 feet (ft)
1 centimeter (cm)	=	0.3937 inch (in)
1 square meter (m^2)	=	1550 square inches (in^2)
1 square meter (m^2)	=	10.76 square feet (ft^2)
1 cubic meter (m^3)	=	35.31 cubic feet (ft^3)
1 liter (l)	=	0.264 US gallons (gal)
1 kilogram (kg)	=	2.20 US pounds (lbs)
1 bar	=	100,000 Pascal (Pa)
100,000 Pascal (Pa)	=	14.50 pounds force per square inch (lbf/in^2)

1.4.2 Temperatures

The temperatures in this manual are primarily indicated in degrees celsius (° C).

To convert °C to °F; multiply by 9, divide by 5 and add 32.

To convert °F to °C; subtract 32, multiply by 5, divide by 9.

As a guide, we have converted below some temperature values from °C to °F:

-10 °C	=	14 °F
0 °C	=	32 °F
5 °C	=	41 °F
20 °C	=	68 °F
38 °C	=	100 °F
100 °C	=	212 °F

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1.4.3 Calcium Hardness

The Calcium Hardness of the cooling water is indicated in milliequivalent/kg (mval/kg) or calcium equivalent of the compound. It is differentiated between ppm (American Hardness), °d (German Hardness), °f (French Hardness) and °e (English Hardness). In this manual the hardness is indicated in ppm. For conversion see below.

	mval/kg	ppm	°d	°f	°e
1 mval/kg	1.0	50.0	2.8	5.0	3.5
1 ppm	0.02	1.0	0.056	0.1	0.07
1 °d	0.357	17.9	1.0	1.79	1.25
1 °f	0.2	10.0	0.56	1.0	0.7
1 °e	0.286	14.3	0.8	1.43	1.0

1.5 Feedback Regarding Documentation

If you have any comments regarding the documentation provided to you, please contact us.

When you contact us, please provide us with

– The document code

– The date of issue

– The page number, section number and, where applicable, the procedure step number

– A description of any errors

– A proposal for improvements

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Telefax	+49 551 68691

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2 FUNDAMENTALS

This chapter briefly describes the most important features, functions, and subassemblies of the laser device. This background information will ease your understanding of the information contained in the subsequent chapters.

The information in this chapter does not enable you to operate or service the COMPex*Pro* excimer laser device.

Never switch on or attempt to operate or service the COMPex*Pro* laser device before reading, understanding and fully familiarizing yourself with Chapter 3 of this manual (Safety)!

NOTE
Topics such as laser physics, optics required for the operation of lasers and the principle of excimer lasers are discussed in detail in the Lambda Physik publication “Excimer Laser Technology: laser sources, optics, systems and applications” (ISBN 3-00-006395-1, available through Lambda Physik).

2.1 The Excimer Laser Device

The COMPex*Pro*™ Series of laser devices are excimer lasers which belong to the category of gas lasers. The term “excimer” is an abbreviation for “*exci*ted di*mer*”, which is a reminder of the excited diatomic molecules that were originally used as a laser gas in the first systems.

Depending on the required laser output wavelength, the active laser medium used by the COMPex*Pro* is either Xenon Fluoride (XeF), Xenon Chloride (XeCl), Krypton Fluoride (KrF) or Argon Fluoride (ArF) or Fluorine (F_2). All of these types of lasers operate in the pulsed mode and emit ultra-violet laser radiation.

– XeF lasers operate at a wavelength of 351 nm,

– XeCl lasers operate at a wavelength of 308 nm,

– KrF lasers operate at a wavelength of 248 nm,

– ArF lasers operate at a wavelength of 193 mm,

– F2 lasers operate at a wavelength of 157 nm.

The required wavelength has to be specified when the laser device is ordered.

The repetition rate, i.e. the frequency at which the laser pulses are fired, is variable up to a predetermined version-dependent maximum.

2.2 Functional Description of the Laser

LASER is an acronym for "*L*ight *A*mplification by *S*timulated *E*mission of *R*adiation". A laser amplifies light and produces coherent light beams. As the waves of coherent light beam propagate in step with one another, laser light can be made extremely intense, highly directional, and very pure in frequency (color).

For laser light to be emitted, three basic components are needed:

– a active laser medium capable for emission of laser light

– an optical resonator for the amplification of the laser light

– and an energy source to stimulate the emission of laser light.

An active laser medium (see Figure 2, A) can be a solid, a liquid or a gaseous material. The COMPex*Pro* uses a gaseous material as active lasing medium, which is contained in its laser tube. The electrons in this laser-active medium are pumped, or energized, to an excited state by an energy source (B). In a process known as *stimulated emission*, they are "stimulated" by external photons to emit the stored energy in the form of photons. The photons thus emitted travel in step with the stimulating photons and, in turn, impinge on other excited atoms to release more photons.

The optical resonator normally consists of two mirrors (C and D) which are placed on two sides of the active laser medium. *Light amplification* is achieved as the photons move back and forth between the two mirrors, triggering further stimulated emissions. A part of the intense, directional, and monochromatic laser light finally leaves the resonator through one of the mirrors (D), which is only partially reflective. COMPex*Pro* laser devices have these two mirrors attached to the rear and front side of the laser tube.

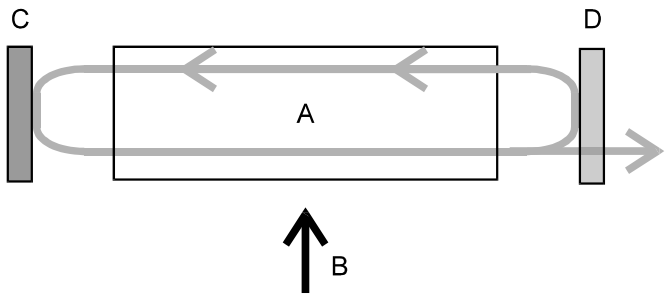

Figure 2: *Laser principle*

Key to Figure 2:

A	Active laser medium	C	Rear mirror
B	Energy source	D	Front mirror

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To stimulate the active lasing medium for emission of laser light an electric discharge is used which is also integrated in the laser tube. The amount of energy needed for the electrical discharge requires high voltages. Therefore COMPex*Pro* laser devices are equipped with a high voltage power supply.

COMPex*Pro* laser devices are designed to emit laser light in pulses. The electrical energy for each laser pulse is stored in an array of capacitors, which are supplied by the high voltage power supply. When a laser pulse is needed, an electronic switch, technically realized by a thyratron, enables the capacitors to be discharged. The electrical energy stored in the capacitors is then transferred to the laser-active medium via an electrical discharge between a set of electrodes in the laser tube, and thus stimulates the laser pulse. For the control of the laser beam energy, COMPex*Pro* laser devices are equipped with an energy monitor.

The internal control of the components in COMPex*Pro* laser devices is achieved by a built-in laser control device, the Communication Interface.

The functional design of the COMPex*Pro* laser device is shown in Figure 3.

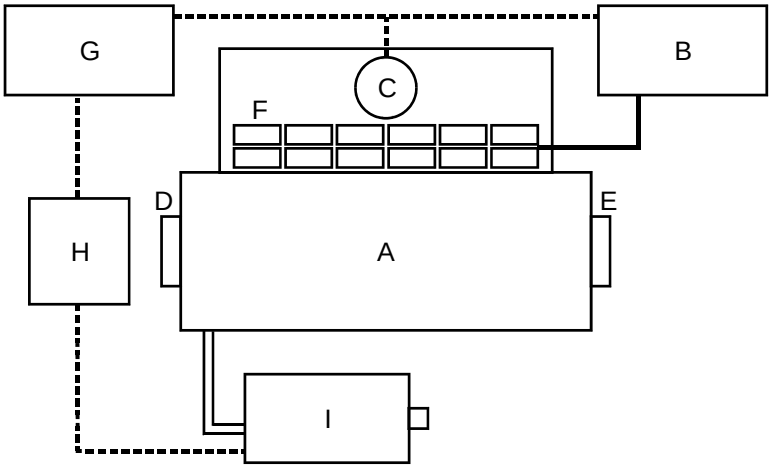

Figure 3: *Functional design of the COMPex*$\mathcal{Pro}$

Key to Figure 3:

A	Laser tube	F	Capacitor array
B	High voltage power supply	G	Communication interface (CI)
C	Thyratron	H	Energy monitor
D	Front mirror (partly reflective)	I	Vacuum pump
E	Rear mirror (high reflective)		

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2.3 System Overview

This section provides an overview of the location and nomenclature of the system components.

2.3.1 Designation of Sides

This section indicates the designation of the sides of the COMPex*Pro* laser device as used throughout this manual.

To prevent confusion or ambiguity in the representations or procedures contained in this manual, the sides of the COMPex*Pro* are defined according to their purpose or function (see Figure 4).

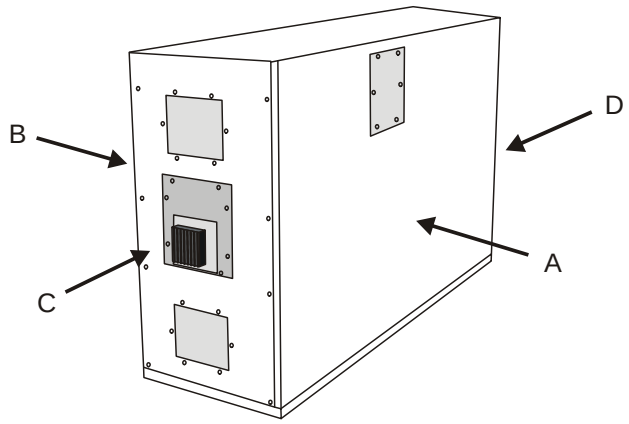

Figure 4: *Designation of the sides of the COMPex*Pro

Key to Figure 4:

A Service side
B Rear side
C Beam exit side
D Connection side

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2.3.2 Exterior Views

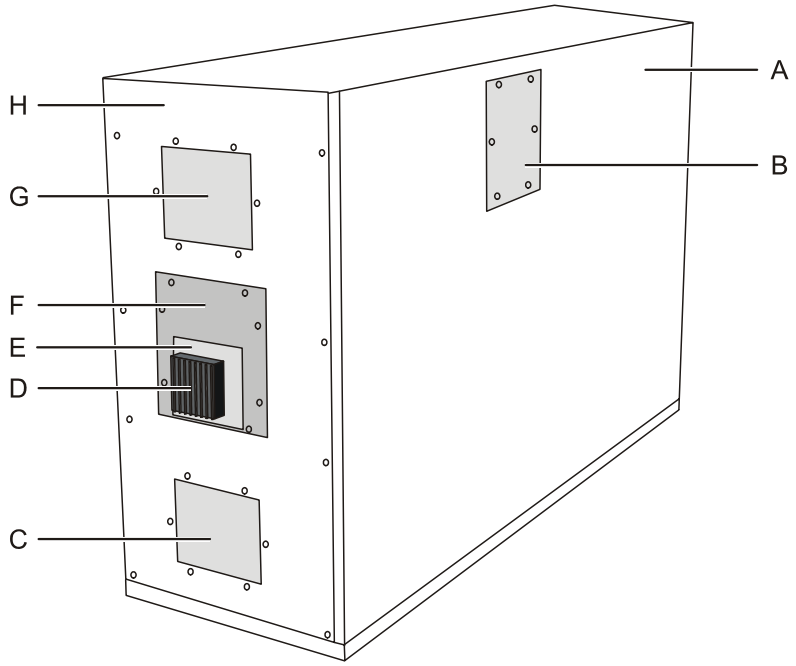

Figure 5: *Beam exit side and service side*

Key to Figure 5:

A Service panel
B Thyratron adjustment plate access panel
C Lower air intake
D Beam shutter
E Beam exit frame
F Front mirror access panel
G Upper air intake
H Front panel

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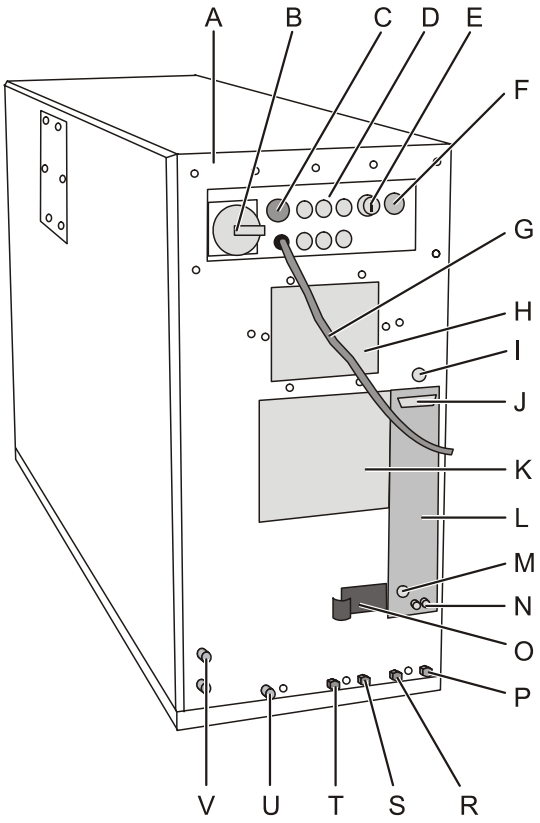

Figure 6: *Connection side and service side*

Key to Figure 6:

A	Rear panel
B	Mains switch
C	Power On lamp
D	Fuses
E	Key switch
F	Control supply lamp
G	Mains supply line
H	Exhaust fan outlet
I	Remote interlock connector
J	RS232 connector
K	Rear mirror access
L	Communication interface access panel
M	LAN feedthrough
N	Trigger BNC connector
O	Vacuum pump power supply
P	Buffer gas connector
R	Rare gas connector
S	Halogen gas connector
T	Inert gas connector
U	Vacuum pump connector
V	Water connection fittings

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2.3.3 Inside View (Except COMPex*Pro* F_2)

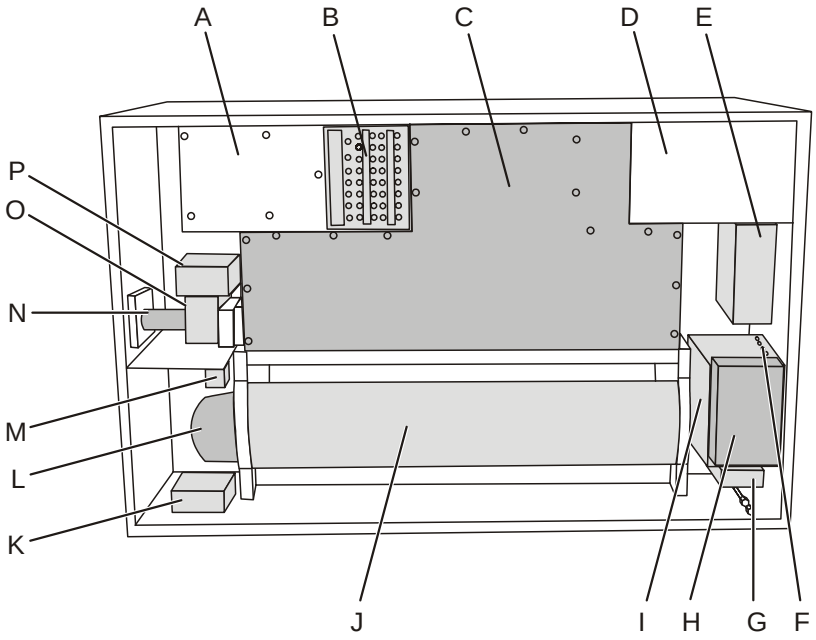

Figure 7: *Inside view*

Key to Figure 7:

A	Thyratron (front) and HV power supply (behind)
B	Thyratron adjustment panel
C	Service panel HV discharge unit
D	Power-On circuit (with key switch, transformer)
E	Communication interface (CI)
F	Fuses
G	Gas valve block
H	Basic module
I	Control box (with transmitter, reveiver, main board)
J	Laser tube
K	Power supply for electrostatic gas purifier
L	Fan motor
M	Pressure sensor
N	Beam shielding
O	Beam splitter box
P	Energy monitor

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2.3.4 Optional Halogen Source

Normally the compressed gas cylinders of the halogen gases used must be stored in specially designed safety gas cabinets. For safety reasons and to ease the use of COMPex*Pro* laser devices Lambda Physik offers the halogen source Halo Safe® as an option. This halogen source allows on-site production of the required halogen, thereby eliminating the need for compressed gas cylinders with hazardous hydrogen fluorine/chloride as well as safety gas cabinets. This drastically simplifies gas handling.

In addition, the halogen source provides purer halogen than tank halogen, thereby reducing contamination of the optics.

2.4 Primary System Components

2.4.1 Laser Tube

The laser tube (NovaTube®) can be considered as the motor of the laser. Figure 8 shows a cutaway drawing of the longitudinally symmetrical laser tube.

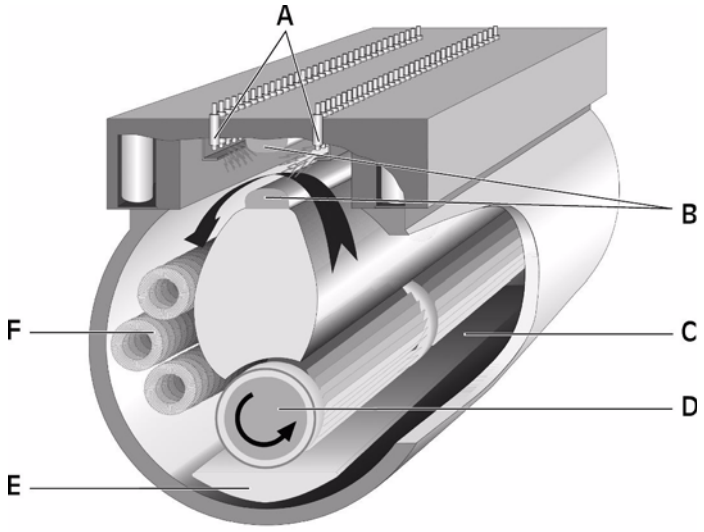

Figure 8: *Cutaway drawing of the laser tube*

Key to Figure 8:

A	Preionization pins	D	Gas circulation fanr
B	Electrodes	E	Dust filter
C	Laser tube	F	Heat exchanger

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The laser tube (C) is the reservoir for the laser gas. The materials chosen allow the problem-free use of excimer gas mixtures. The material surfaces become coated with a layer of halogen metal complex. This process, resulting from a reaction between halogen (laser gas) and metal (material within tube), is called passivation. Passivation renders the material surfaces within the tube chemically inert to halogen.

A repetition of this process, known as re-passivation, is always required if the surface passivation has been damaged as a result of air entering the laser tube or when the laser device or laser tube has been transported or stored for longer periods.

A high voltage discharge between the electrodes (B) transfers the energy to the excimer gas mixture (e. g. fluorine or krypton premix). In order to obtain a controlled, spark-free discharge, the laser gas has to be preionized, i. e. a sufficiently high density of free charged molecules has to be created between the electrodes. This is achieved with preionization pins (A) arranged along the main electrodes. The result is a homogeneous preionization of the laser gas. The switching of preionization and main discharge in series ensures a perfect synchronization between preionization and main discharge.

After the high-voltage discharge, thermal inhomogenities in the laser gas arise in the discharge area. Therefore, the gas volume in the discharge area has to be completely exchanged between two laser pulses. A transverse circulation fan (D) positioned within the laser tube causes the gas volume between the main electrodes to be completely replaced between two successive laser pulses. The circulation fan is driven externally via a magnetic coupling by a single-phase motor.

The energy efficiency of the excimer laser is to the order of 2%, i. e. the main part of the energy supplied has to be carried away in the form of heat. The gas, heated up by the discharge, reaches the heat exchangers (F) as a result of the flow in the laser tube and is cooled down to the correct operating temperature (approx. 30 °C or 86 °F).

Each discharge pulse of the laser results in a load on the preionization pins and main electrodes and causes a slightly erosion of material. Percipitation of the created particles on the laser windows would result in diminishing beam intensity by scattering and absorption. Therefore these particles must permanantly be removed from the laser gas which is done by an electrostatic filter (E) integrated in the gas circulation. Due to the pressure conditions generated by the circulation fan, the laser gas continuously flows through this electrostatic filter

The maintenance operations required during the lifetime of the NovaTube® are new gas fills and the exchange of the windows. To minimize downtimes, the windows should be stored as premounted units.

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2.4.2 Resonator Optics

The optical feedback system that amplifies the laser light is provided by a plane-parallel resonator (see Figure 9).

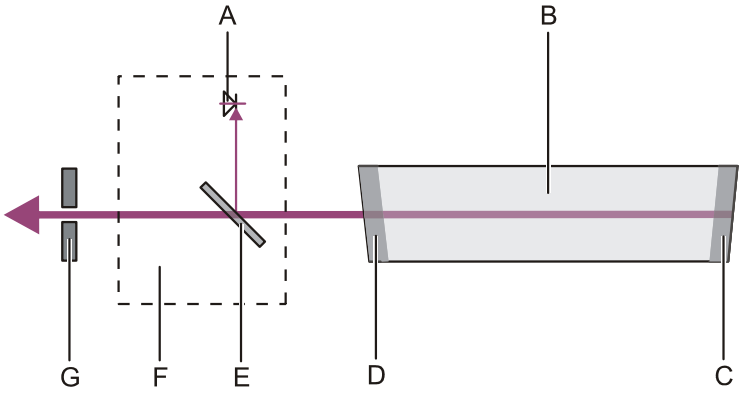

Figure 9: *Laser resonator and energy monitor*

Key to Figure 9

A	UV photodiode	E	Beam splitter
B	Laser tube	F	Energy monitor
C	Rear mirror (highly reflective)	G	Shutter
D	Output coupler		

At the rear of the resonator is a highly reflective (HR) mirror (C). The other resonator mirror (D) is known as the output coupler. This is a partially reflective (PR) mirror that allows part of the laser light to escape from the resonator, thereby forming the laser beam.

The gas volume of the laser tube (B) is sealed by the mirrors (C, D) which are attached on each side of the laser tube.

2.4.3 Energy Monitor

The internal energy monitor (see Figure 9, F) is situated between the output coupler (D) and beam shutter (G). A portion of the beam emitted through the output coupler is diverted by a beam splitter optic (F) and reflected through attenuators to a UV photodiode (A). The output from the UV photodiode is converted to a voltage signal. The peak value of this signal is digitally encoded and transmitted to the communication interface.

As the energy monitor does not supply absolute measured values, it has to be calibrated according to an externally measured energy reading. In addition to an external measuring device, no further measures are required, calibration is performed using the laser control software's dedicated calibration procedure that can be accessed through the handheld keypad or external PC.

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2.4.4 High Voltage Circuit

The high voltage (HV) circuit provides the rapid high-voltage discharge required to obtain efficient excitation of the laser gas. The primary components of the HV circuit are the HV power supply module (see Section 2.4.4.1 on page 20), thyratron (see Section 2.4.4.2 on page 20) and storage capacitors as well as the discharge electrodes and peaking capacitors of the NovaTube® (see Section 2.4.1 on page 16).

The duration of the high-voltage discharge is about 50 ns and the peak power can reach one gigawatt. The discharge is fed from peaking capacitors. These are a large number of discrete ceramic high-voltage capacitors coupled directly to the laser tube's discharge electrodes with minimum inductance.

The peaking capacitors are charged from a current pulse supplied from the storage capacitors. The storage capacitors are charged by the HV power supply module between laser pulses. As soon as the storage capacitors are charged, the laser is ready to pulse. The laser pulse is triggered by the HV switch (thyratron), which switches the recharging of the storage capacitors. The working principle of the high voltage circuit is shown in Figure 10.

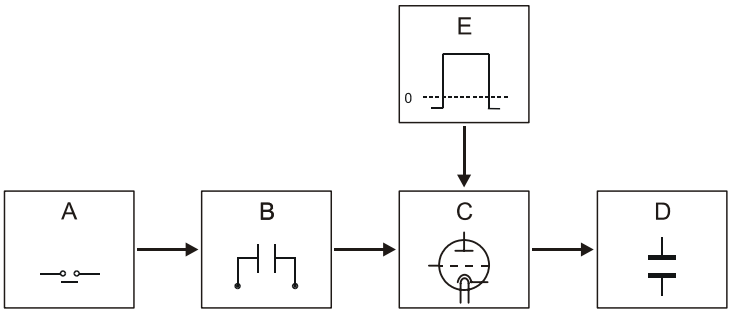

Figure 10: *Layout of the high voltage circuit*

Key to Figure 10:

A HV power supply
B Storage capacitors
C Thyratron
D Peaking capacitors of the discharge unit
E HV trigger generator

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2.4.4.1 HV Power Supply

The HV power supply module is a high voltage, switching power supply specifically designed for charging capacitors in laser systems. Incorporated is a high-performance control module that precisely regulates the output voltage, automatically compensating for line, load, temperature, repetition rate and program voltage variations. The HV power supply module converts mains current into the high voltage DC required by the discharge circuit.

2.4.4.2 Thyratron

The laser uses a simple 3-inch hydrogen thyratron, a thermionic tube. It is used as an active switch to discharge the storage capacitors. The anode of the thyratron is connected to the charging voltage. The cathode is connected to ground. Between these two main electrodes is the control grid, which initiates the discharge (switching) of the thyratron.

As is also the case with conventional thermionic tubes, the cathode structure has to be heated in order to ensure sufficient emission of starting electrons. If the electron emission after a longer operating period is no longer sufficient to initiate switching of the thyratron, this can be corrected during the thyratron lifetime by increasing the heating power of the cathode.

Hydrogen is necessary to provide a fast current increase and a high current intensity. However, as hydrogen is continually lost due to diffusion and metal erosion, the concentration of hydrogen has to be continually renewed. For this purpose, there is a reservoir structure (palladium) in the tube, in which a large quantity of hydrogen is stored. By heating the reservoir, hydrogen is released from the reservoir into the main thyratron. It should be noted, however, that too much hydrogen reduces the hold-off voltage between the electrodes of the thyratron to such a level that unwanted switching of the thyratron will take place even without the trigger pulse. On the other hand, if the partial hydrogen pressure in the thyratron is too low, the laser is unable to pulse. This is because there is no discharge in the thyratron due to a lack of charged particles.

The values for the two heating voltages, U_H for the cathode heating and U_R for the hydrogen reservoir voltage, are critical to the correct operation of the tube. The voltages are stabilized in a broad input voltage range in order to be unaffected by voltage fluctuations in the supply line (spikes). These values have to be altered during the total life of the thyratron to ensure proper switching of the tube. This can be done simply by using the jumpers provided for this purpose. You will find a description of the thyratron adjustment in Section 7.10 of this manual.

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2.4.5 Laser Control

The fundamental layout of the control system for the COMPex*Pro* is shown in Figure 11.

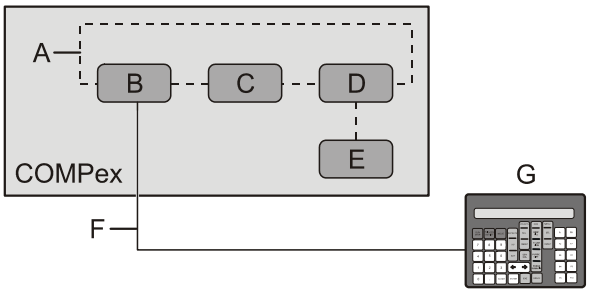

Figure 11: *Laser control system with handheld keypad*

Key to Figure 11:

A	FOL data ring	E	HV power supply module
B	Communication interface (CI)	F	RS232 connection
C	Energy monitor	G	Handheld keypad
D	Basic module		

The communication interface (CI, see Figure 12, B) is the central control module. Partial tasks are carried out independently by dedicated submodules such as the energy monitor (C), basic module (D) and the HV power supply (E). Each of the submodules has an address assigned to it which can be actuated by the CI.

The individual modules communicate through a data ring (A) made up of fiber optic lightwave guides (FOLs). The information is optically coded by the CI and given to or received by the data ring as a sequence of light pulses. As the FOL data ring cannot pick up or trasmit interference due to electromagnetic radiation (such as that generated through the fast high voltage discharge), this system ensures safe, interference-free communication within the laser device.

The user interface to the laser control system is the handheld keypad (G) or external control PC (remote PC). These devices communicate with the CI through the serial interface (RS232) situated on the connection side of the laser head.

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Figure 12 (right) shows the handheld keypad which provides a comfortable way to operate the COMPex*Pro* laser device. The communication interface (Figure 12, left) also supports the input of externally generated trigger pulses (EXT TRIG.) and the output of synchronisation pulses (SYNC OUT).

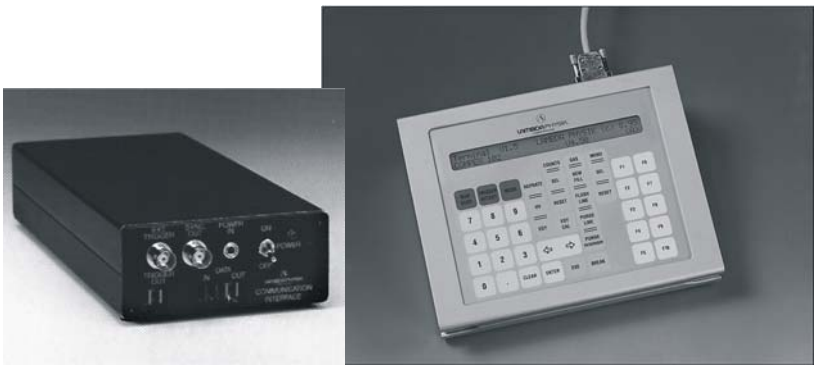

Figure 12: *Communication interface and handheld keypadr*

2.4.6 Electrical System

The laser device is connected to a single-phase power supply. The individual consumers in the laser device are either connected to the mains voltage circuit single or to a 24 V DC circuit.

The mains voltage consumers in the laser device include the HV power supply module, gas circulation fan and vacuum pump as well as the cooling and exhaust fans.

The 24 V DC power supply serves the low voltage consumers. These include the solenoid gas valves, gas purifier and various decentralized control modules.

The components in the electrical system are not subject to routine maintenance.

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2.4.7 Gas Supply / Exhaust System

The required excimer laser gases are supplied from an external source through dedicated supply lines. In the case of fluorine, the gas can either be supplied from a gas cylinder or from a halogen source (fluorine source).

The gases are mixed for laser operation in the laser tube. The gas evacuated from the laser tube is filtered, so that it is free of halogens, and then blown out through the exhaust.

The inlet and evacuation of gases is controlled by solenoid valves actuated through signals received through the FOL data ring.

The layout of the gas supply and exhaust system is shown in the following diagrams.

– Figure 13 shows the layout of the gas supply / exhaust system when the halogen is supplied from a gas cylinder.

– Figure 14 shows the layout of the gas supply / exhaust system when the halogen is supplied from a halogen source (fluorine source). The function of the halogen source is, however, not described in this section as this is explained in more detail in a separate manual that will be provided if the laser is equipped with a halogen source.

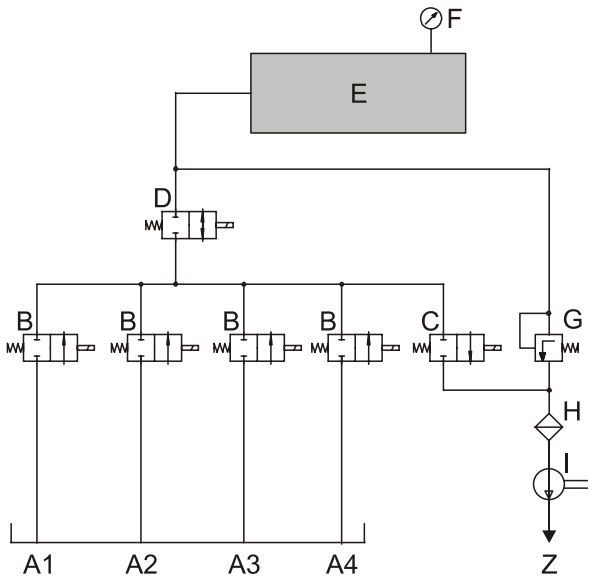

Figure 13: *Laser gas supply / exhaust without halogen source*

Key to Figure 13:

A	Gas connection (1 = Buffer, 2 = Rare, 3 = Inert, 4 = Halogen)
B	Excimer laser gas valve (Buffer, Rare, Inert, Halogen)
C	Vacuum valve
D	Laser tube (head) valve
E	Laser tube (NovaTube®)
F	Laser tube pressure sensor
G	Pressure relief valve
H	Halogen filter
I	Vacuum pump
Z	Exhaust

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The individual gas supply lines are connected to the laser device at the corresponding connections situated on the connection side of the laser head (see Figure 6).

The gas solenoid valves (B) are normally closed. They are opened to allow the corresponding gas to flow into the gas manifold.

The vacuum valve (C) is a solenoid valve that is normally closed. It is opened to allow the gas in the gas manifold to be pumped out through the exhaust by the vacuum pump.

The head valve (D) is a solenoid valve that is normally closed. It is opened to allow the gases to flow from the gas manifold into the NovaTube® (E).

The pressure sensor (F) situated at the rear of the NovaTube® provides a tube pressure reading that can be polled through a software command.

The pressure relief valve (G) opens when the pressure in the NovaTube® is too high.

The halogen filter (H) removes molecular species of halogen gas from the laser gas mixtures exhausted from the NovaTube®.

The vacuum pump (I) exhausts the gases from the NovaTube®. It is started and stopped through signals received through the FOL data ring.

Apart from turning on the externally supplied gases and regulating the pressure of the gases in the external gas circuits, the gas supply and exhaust requires no operation or routine maintenance.

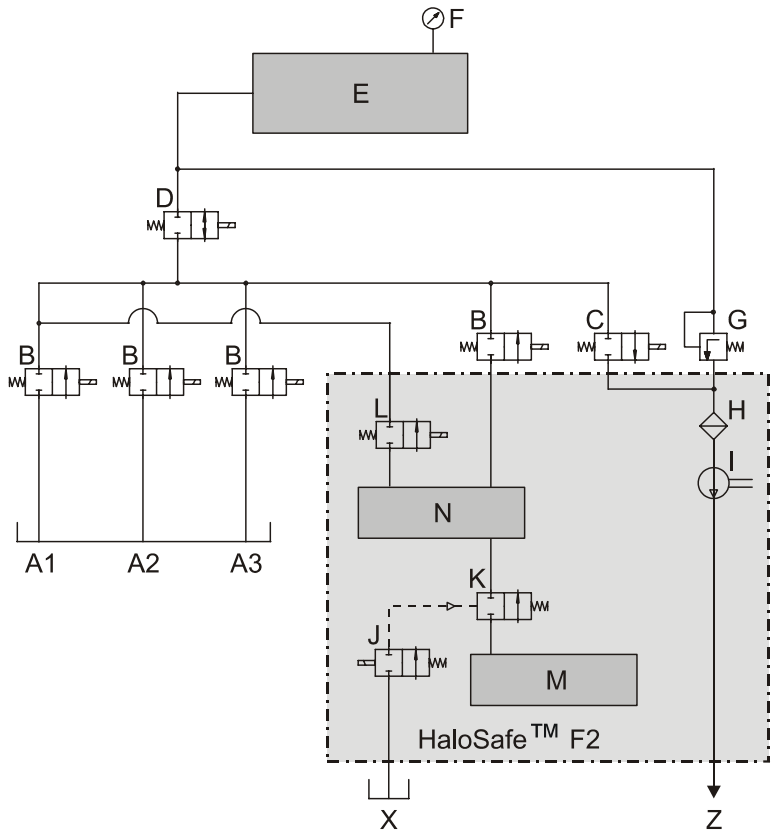

Figure 14: *Laser gas supply / exhaust with fluorine source*

Key to Figure 14:

A	Gas connection (1 = Buffer, 2 = Rare, 3 = Inert)
B	Excimer laser gas valve (Buffer, Rare, Inert, Halogen)
C	Vacuum valve
D	Laser tube (head) valve
E	Laser tube (NovaTube®)
F	Laser tube pressure sensor
G	Pressure relief valve
H	Halogen filter
I	Vacuum pump
J	Pilot valve
K	Fluorine valve
L	Halogen-Buffer valve
M	Reactor
N	Accumulator
X	Control pressure connection (6.5 bar)
Z	Exhaust

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2.4.8 Cooling System

The efficiency of commercial excimer lasers is theoretically in the region of between 1 and 4 %. The remaining energy is almost completely converted to heat and has to be eliminated by an effective cooling system.

COMPex*Pro* laser devices are air cooled. They use environmental air for cooling. The COMPex*Pro* 110, COMPex*Pro* 205 and COMPex*Pro* F_2, however, also require water cooling when they are continually operated at repetition rates exceeding 20 Hz.

Air Cooling

The laser device has two air inlets on the beam exit side (see Figure 5 on page 13, G) and a central exhaust outlet on the connection side (see Figure 6 on page 14, H). As the laser gas is evacuated through a separate connection, the exhausted air does not contain any toxic gases or byproducts. Nevertheless, in certain failure scenarios, the exhaust gas may contain a small concentration of halogen gas or ozone. The exhaust should, therefore, be connected to a suitable industrial extraction system which enables the gases to be appropriately treated.

Water Cooling

The cooling system cools the laser tube (NovaTube®) through tap water. The layout of the cooling water circuit is shown in Figure 15.

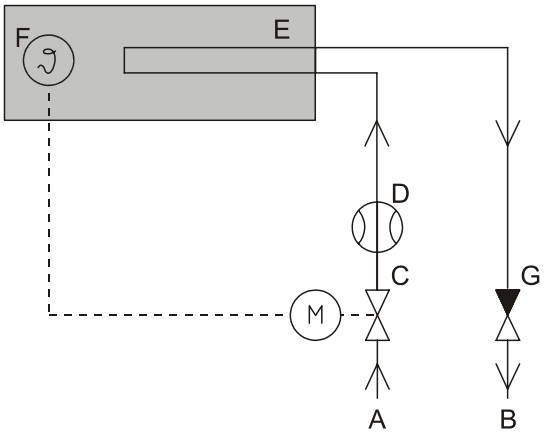

Figure 15: *Cooling water circuit*

Key to Figure 15:

A	Cooling water inlet	E	Laser tube
B	Cooling water outlet	F	Laser tube temperature sensor
C	Flow regulating valve	G	Check valve
D	Water flow sensor		

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The external cooling water supply and drain is connected to the laser device at the inlet (A) and outlet (B) connections situated on the connection side of the laser head.

The flow sensor (D) ensures that sufficient water flows into the laser device. If the water flow is not sufficient, an interlock is activated.

The Temperature sensor (F) monitors the temperature in the NovaTube® (E). If the temperature is too high or too low a signal is sent to the flow regulating valve (C). This automatically increases or decreases the water flow as required to ensure that the respective module operates at the correct temperature.

The check valve (G) ensures that cooling water does not re-enter the laser device at the cooling water outlet.

Apart from turning on the external water supply and ensuring that the outlet water flows into an appropriate drain, the cooling water circuit requires no operation or routine maintenance.

2.4.9 Purge Gas System

UV light reacts with oxygen to create ozone. Apart from creating a health hazard (for more information, see Section 3), this oxidizes the surface of the optics and decreases laser performance.

To prevent ozone production, the beam path can be purged with nitrogen (purge gas).

The external purge gas supply is connected to the corresponding connection on the laser head. The pressure of the purge gas entering the purge gas system is monitored by a pressure switch.

Apart from turning on the externally supplied purge gas and regulating the pressure of the gas in the external circuit, the purge gas supply requires no operation or routine maintenance.

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2.5 Monitoring and Fail-Safety Systems

2.5.1 Watchdogs

The COMPex*Pro*, like all of Lambda Physik excimer lasers using serial data rings, has watchdogs to ensure functional checks. Watchdogs are switches which alter the logical level as soon as the reset pulses stop.

The watchdog is reset by the control at least three times a second. Should the pulses stop, as in the case of a breakdown, this is recognized by the watchdog belonging to the module. The module is switched to a safe, inactive state.

2.5.2 Data Ring Selftest

After the system is booted, a self-test is automatically carried out in order to test the data ring and the modules for error-free interaction. The serial structure of the data ring requires all modules working properly and the controller receiving a correct response for a transmitted signal. If this does not occur, the controller sends a failure message. In this situation it is not possible for the controller to localize the error.

In case of a malfunction, the control interrupts the transmission of light signals in the data ring. To locate the defective module, the laser device has to be restarted.

2.5.3 Interlocks

'Interlock' refers to an error message indicating a malfunction or critical interference in the functioning of the laser.

The response of the laser to the interlock may vary; when the user needs to be protected, the laser is completely switched off. When the malfunction is correlated to the laser only, the high voltage is switched off and disabled.

The advantages of this method are:

– no need for the entire system to be restarted in case of a straight-forward malfunction,

– communication with the processor is still possible.

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2.5.4 External Interlock and Laser Warning Lamp

Dedicated contacts are provided to secure the room in which the COMPex*Pro* is operating through one or more remote interlock switches (e.g. door switches) and an external warning lamp.

If the circuit conncted to the remote interlock contacts is interrupted (e.g. by opening a door), the HV power supply will be shut down, thereby preventing laser radiation from being generated. As soon as the contacts are closed again, the laser can be restarted. When a restart after activation of an external interlock is to be prevented, the contacts will have to be intergrated into an emergency off circuit.

The external warning lamp will light as soon as laser radiation is emitted.

For further information about the external interlock and warning lamp contacts, please refer to Section 4.3.8.2 on page 95.

2.6 Pulse Triggering Modes

The COMPex*Pro* operates as a pulsed laser. The discharge and, consequently, the emission of the individual laser light pulses can be triggered either internally or externally.

– With internal triggering, the laser light pulses are triggered by the laser device's internal trigger generator. Triggering occurs continuously at the repetition rate (rep. rate) set by the user through the laser control software (see Section 8.3.4.6 on page 278).

– With external triggering, the laser light pulses are triggered from an external trigger generator that is connected to the external trigger socket on the industrial computer (see Section 4.3.8.3 on page 96).

A0510COMPPRO

2.7 Energy Management

The pulse energy (output energy) of an excimer laser is dependent upon the charging voltage (high voltage) and condition (age) of the excimer laser gas.

When the pulse energy (E) is considered as a function of the charging voltage (U), the result is approximately the function shown in Figure 16.

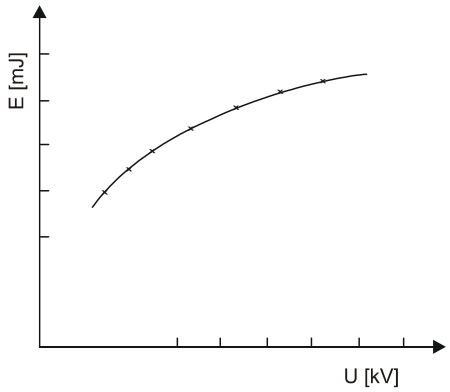

Figure 16: *Pulse energy as a function of charging voltage*

As excimer laser gases age, the pulse energy obtained from a given charging voltage will decrease. Consequently, the COMPex*Pro* can be operated in one of two fundamental running modes: the Energy Constant mode (EGY CONST) or the High Voltage (HV) Constant mode (HV CONST).

Regardless of the running mode used, the laser gas quality will reach a state which is insufficient to adjust the HV power supply at a level that provides the preset beam output energy. In this case, the laser gas is to be exchanged completely using the New Fill procedure. The New Fill procedure requires special interaction with the user or Remote PC.

2.7.1 Fundamental Running Modes

When the *Energy Constant* mode is selected, the laser control continuously adjusts the high voltage to achieve laser operation at a preset energy level (see Figure 17).

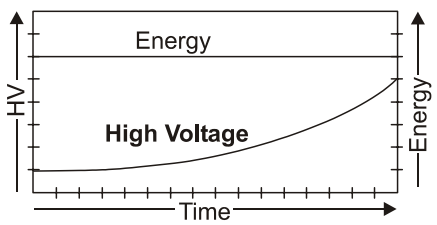

Figure 17: *Voltage increase in the Energy Constant mode*

When the *HV Constant* mode is selected, the pulse energy decreases with time as excimer laser gases have a limited lifetime (see Figure 18).

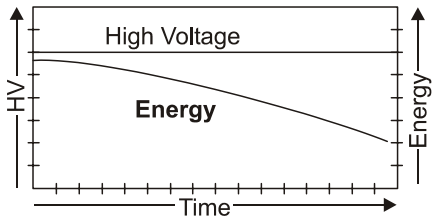

Figure 18: *Energy decrease in the HV Constant mode*

Most applications require the energy constant mode, whereas the high voltage constant mode is primarily used for diagnostic purposes (e.g. to measure the gas lifetime).

2.7.2 Constant Energy Operation With Gas Actions

If excimer lasers are operated continuously, the pulse energy as a function of time and particularly as a function of the number of laser pulses shows a clear drop. Reasons for this drop are:

– The halogen concentration in the laser gas slowly decreases, because the highly reactive halogen enters into a variety of stable compounds, particularly when the laser is operated at higher repetition rates.

– Impurities and reaction products accumulate in the laser gas.

– The intense laser radiation in the resonator causes small particles generated by the electrode burn-off to condense on the optics with chemical reactants from the laser gas.

In order to keep the desired pulse energy of the laser constant, the laser control software's Partial Gas Replacement (PGR) mode can be selected. In this mode, various gas actions are performed after a given number of laser pulses, after a given time period or when a predefined HV level or laser tube pressure is reached. The gas actions performed in the PGR mode can be fundamentally classified as halogen injections (see Section 2.7.2.1) and partial gas replacements (see Section 2.7.2.2).

2.7.2.1 Halogen Injections

Halogen concentration decreases slowly, even in well passivated systems. This leads to lower pulse energy. A portion of halogen is, therefore, added to the gas fill to compensate for the loss of halogen partial pressure. This action is known as a halogen injection (HI).

A0510COMPPRO

Halogen injections are carried out when the high voltage (HV) reaches a predefined value for the gas refreshment action. This value is referred to in Figure 19 as the replacement value (HV_{repl}).

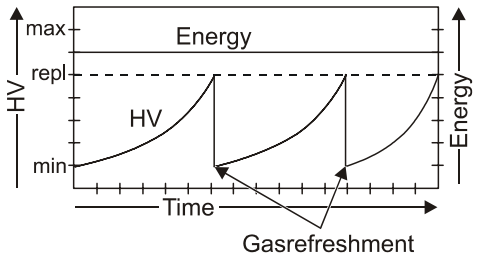

Figure 19: *Charging current with halogen injections*

2.7.2.2 Partial Gas Replacements

The partial gas replacement (PGR) is used to adjust the composition of the gas mixture to the original value and remove impurities which may have built up during laser operation or idle time. In addition, the PGR adjusts the gas pressure in the laser tube, which is increased by numerous micro halogen injections, back to the normal level.

During the PGR, laser gas is released through the halogen filter and halogen, rare and buffer gases are refilled accordingly, dependent on the preset gas partial pressures.

According to the control software configuration a PGR is requested:

– when a given number of pulses is reached

– after a given time period has elapsed

– after a predefined increase in the laser tube pressure has occurred

– when the HV reaches the predefined replacement value and the previous halogen injections did not sufficiently reduce the HV level (see Figure 20).

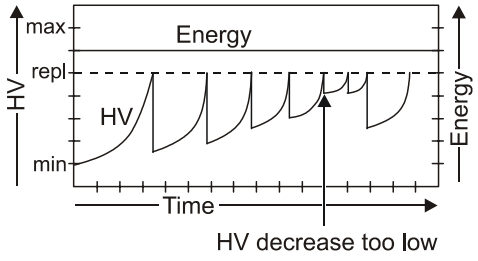

Figure 20: *Charging current with Partial Gas Replacement*

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2.7.2.3 HI/PGR Algorithm

The constant energy mode with gas actions (HIs and PGRs) is known as EGY CONST PGR. The sequence of operations in this mode is as follows:

– If HV regulation reaches HV_{repl} after the warm-up period, a HI is performed.

– If the HI is successful, i. e. the HV level decreases after the HI to less than HV_{repl} -0.6 kV, the next gas replenishment will be a HI. If the controller already has performed three successful HIs in series, the next gas action will be a PGR to adjust all partial gas pressure.

– If an HI is not successful, i.e. The HV-level does not decrease to less than HV_{repl} -0.6 kV, a PGR will be performed when the HV level again reaches HVrepl (see Figure 20).

– If a PGR is successful, i.e. the HV-level decreases after the PGR to less than HV_{repl} -0.6 kV, the next gas replenishment action will be a HI again.

– If a PGR is not successful, i.e. the HV-level does not decrease after the PGR to less than HV_{repl} -0.6 kV, then the next gas replenishment action will be a PGR.

– If three PGRs in series are not successful, the message “Preset energy too high” will come up when HV_{repl} is reached again when more than 64 pulses have been fired since the last PGR.

– When HV_{max} is reached laser operation will be stopped.

A0510COMPPRO

Figure 21 shows a flow diagram for laser operation in the EGY CONST mode with PGR (partial gas replacement)

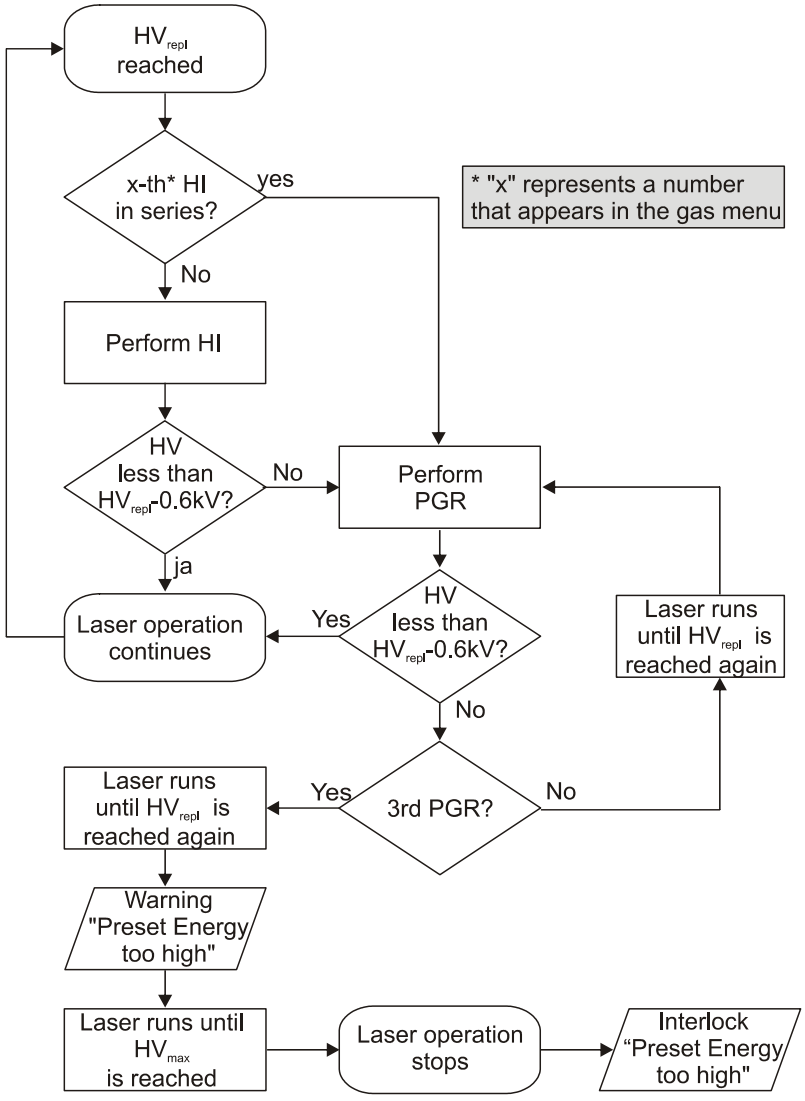


Figure 21: *EGY PGR flow diagram*

A0510COMPPRO

2.7.3 Constant Energy Operation Without Gas Actions

The No Gas Replacement (NGR) operating mode is a constant energy mode without any gas replenishment.

When the high voltage reaches the level HV_{repl} the message “Preset Energy too high” appears to indicate that a new gas fill is needed. Laser operation will be continued until HV_{max} is reached. The laser then shuts off automatically (see Figure 22).

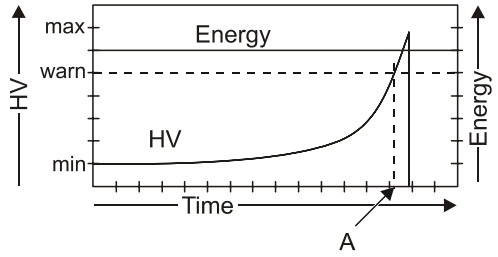


Figure 22: *Charging current with No Gas Replacement (NGR)*

Figure 23 shows a flow diagram for laser operation in the EGY CONST mode with NGR (no gas replacement).

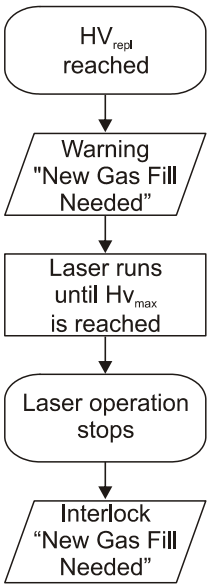
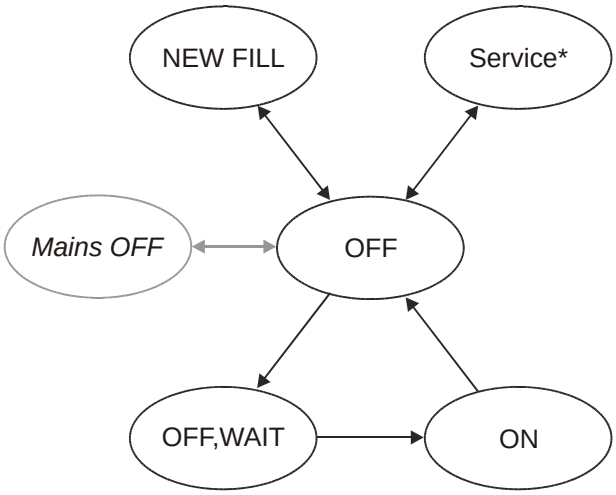

HV repl reached
Warning "New Gas Fill Needed”
Laser runs until Hv max is reached
Laser operation stops
Interlock “New Gas Fill Needed”

Figure 23: *EGY NGR flow diagram*

A0510COMPPRO

2.8 Operating Modes

Figure 24 provides an overview of the available operating modes and the possible transitions between these modes. These operating modes are briefly described in the following subsections..



*PASSIVATION FILL, TRANSPORT FILL, PURGE <xy> LINE, ENERGY CAL, CAPACITY RESET, HI, PGR etc.

Figure 24: *Operating mode transition diagram*

2.8.1 OFF Mode

The laser control software automatically selects the OFF mode after switching on the laser device. The OFF mode can also be selected by the user from the ON mode to stop laser operation.

In the OFF mode, all laser device system modules, except the high voltage (HV) power supply, are switched on. No laser operation occurs (no emission of laser radiation). The gas circulation fan in the laser tube runs to ensure that the laser gas is at working temperature.

This mode should be selected if the laser device is not directly in use. Gas actions like PGRs and New Fills can this be reduced as the laser gas is not being exhausted .

From the OFF mode, the user can select service actions, start the laser or switch off the laser. Before reaching the ON mode, the laser passes through the OFF, WAIT mode.

A0510COMPPRO

2.8.2 OFF, WAIT Mode

The temporary OFF, WAIT mode is automatically passed through when the laser is starting. In this mode, the laser controller waits for the HV power supply to enter standby and the gas circulation fan to start. This condition remains for approx. 5 seconds.

2.8.3 ON Mode

The ON mode can only be started from the OFF mode. In this mode, the HV power supply is switched on and laser operation starts with the currently active operating mode (energy management selection) and parameter settings.

When the laser is in the ON mode and the shutter is open, the workpiece will be irradiated with laser light pulses.

For short breaks in laser operation, the shutter can be closed. If a longer break is necessary, it is advisable to switch back to the OFF mode.

2.8.4 NEW FILL Mode

The NEW FILL mode is actuated by the user to execute a complete refill of the laser tube. The complete gas mixture is pumped out of the laser tube and replaced by fresh gas.

The NEW FILL mode is actuated from the OFF mode. At the end of the new fill, the OFF mode is automatically reactivated.

2.9 Laser Operation

All operating modes and laser parameters can be set and the status requested from the communication interface through the handheld keypad or external PC connected to the laser device's serial interface. The status of the laser device is indicated by a status code that is indicated on the handheld keypad display (see Section 6.1.3.1 on page 142) or output through the serial interface together with the currently active operating mode. The meaning of the individual status codes is described in Section 8.2.4 on page 270.

If a status code indicates an interlock or error that requires interaction with the user, solve the problem according to the information given in Section 8.2.4 on page 270.

A0510COMPPRO

3 SAFETY

Never switch on or attempt to operate or service the COMPex*Pro* before reading, understanding and fully familiarizing yourself with the contents of this chapter.

This chapter is divided into three sections:

– General Safety Aspects, which explains aspects relating to the safe operation of the laser device.

– Special Safety Aspects, which outlines the risks specific to working procedures with and on this laser device.

– Overview of safety-relevant labels, which shows the design of and describes the safety labels.

3.1 General Safety Aspects

3.1.1 Applicable Standards

The equipment has been tested and found to comply with the following standards and directives about safety of laser products:

– IEC 60825-1 (1994) + A11 (1996)
(IEC 825-1: 1993)

– IEC 61010-1 (1990) + A1 (1992) + A2 (1995)

– EN 61010-1 (1993) + A2 (1995)

– CAN-CSA 22.2 No. 1010.010-30

– UL 3101-1

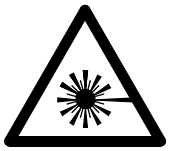
– Low voltage directive (73/23/EEC)

– Pressure equipment directive (97/23/EG)

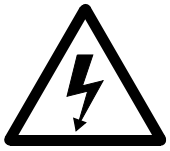
All laser products from Lambda Physik are compatible with the European laser safety standard EN 60825.

3.1.2 Basic Operation and Designated Use

The COMPex*Pro* laser device has been built in accordance with state-of-the-art standards and recognized safety rules. Nevertheless, its use may constitute a risk to life and limb of the user or of third parties or cause damage to other material property.



WARNING
Potential eye and skin burns!
Only use the laser in accordance with its designated use. Safety interlocks are only to be defeated by authorized personnel.



WARNING
Electrical hazard!
Safety interlocks are only to be defeated by authorized personnel.

WARNING!
Toxic hazards!
The gas system of an excimer laser contains a mixture of halogen gases (fluorine or hydrogen chloride). Inhalation of, or skin contact with, halogen gases should be avoided.

The laser device shall only be used in technically perfect condition and in accordance with its designated use and the instructions set out in this manual, and only by safety conscious persons who are fully aware of the risks involved in operating the laser device. Any functional disorders, especially those affecting the safety of the laser device, should therefore be rectified immediately.

The COMPex*Pro* laser device is a UV laser light source that is primarily designed for use in high-end scientific and medium duty-cycle industrial applications. Using the laser device for purposes other than those mentioned above is considered contrary to its designated use. The manufacturer/supplier cannot be held liable for any damage resulting from such use. The risk of such misuse lies entirely with the user.

Operating the laser device within the limits of its designated use also involves observing the instructions that are set out in this manual as well as complying with inspection and maintenance directives.

A0510COMPPRO

3.1.3 Organizational Measures

In accordance with the valid national regulations for prevention of accidents (in Germany: VBG 93, in the USA: ANSI Z 136.1), a responsible person should be designated as the Laser Safety Officer (LSO) with the responsibility to effect the knowledgeable evaluation of laser hazards and to monitor and enforce their control.

The instruction manual must always be at hand at the place of use of the COMPex*Pro* laser device. In addition to the instruction manual, observe and instruct the user in all other generally applicable legal and other mandatory regulations relevant to accident prevention and environmental protection. These compulsory regulations may also deal with the handling of hazardous substances and the issuing and/or wearing of personal protective equipment.

WARNING
Risk of serious injury through incorrect operation!
Personnel entrusted with work on the COMPex*Pro* laser device must have read the instruction manual and in particular the safety instructions before beginning work. Reading the instructions after work has begun is too late.

The necessity of reading the instruction manual applies especially to persons working only occasionally on the COMPex*Pro*, e.g. during setting up, service or maintenance.

Use personal protective equipment (PPE), e.g. protective eyewear, wherever required by the circumstances or by law (see Section 3.2.2 on page 49 or the separate Site Preparation Manual).

Ensure that all safety-relevant labels are attached to the laser device in accordance with the label location diagrams in Section 3.3 on page 61. Make sure that these labels are always complete and perfectly legible. If any labels are missing, immediately inform Lambda Physik.

In the event of safety relevant modifications or changes in the behaviour of the COMPex*Pro* during operation, stop the laser device immediately and report the malfunction to the competent authority/ person (e.g. Lambda Physik Service).

Never make any modifications, additions or conversions which might affect safety without the supplier’s approval. This also applies to the installation and adjustment of safety devices and valves.

Spare parts must comply with the technical requirements specified by the manufacturer. Spare parts from original equipment manufacturers can be relied upon to do so.

Never modify the software of programmable control systems.

Adhere to prescribed intervals or those specified in the instruction manual for routine checks and inspections.

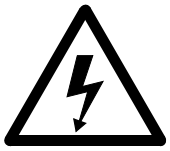
For the execution of maintenance work, tools and workshop equipment adapted to the task on hand are absolutely indispensable.

3.1.4 Selection and Qualification of Personnel - Basic Responsibilities

Make sure that only authorized personnel works on or with the COMPex*Pro* laser device. Statutory minimum age limits must be observed.

Employ only trained or instructed staff and set out clearly the individual responsibilities of the personnel for operation, set up, maintenance and repair.

Do not allow persons to be trained or instructed or persons taking part in a general training course to work on or with the COMPex*Pro* laser device without being permanently supervised by an experienced person.



WARNING
Potential electrical hazards!
Work on the electrical system and equipment of the COMPex*Pro* laser device must be carried out only by a skilled electrician or by instructed persons under the supervision and guidance of a skilled electrician and in accordance with electrical engineering rules and regulations.

WARNING
Toxic hazards!
Work on gas fuelled equipment may be carried out by specially trained personnel only.

3.1.5 Safety Instructions Governing Specific Operational Phases

Take the necessary precautions to ensure that the COMPex*Pro* laser device is used only when in a safe and reliable state.

Operate the laser device only if all protective and safety oriented devices, such as removable safety devices, emergency shut off equipment and exhausters, are in place and fully functional.

In the event of malfunctions, stop the laser device immediately and lock it. Have any defects rectified immediately.

Before starting the laser device ensure that nobody is at risk.

Never switch off or remove suction and ventilation devices when the laser device is in operation.

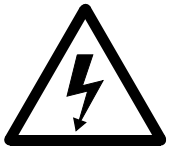
Observe the adjusting, maintenance and inspection activities and intervals set out in the instruction manual, including information on the replacement of parts and equipment. These activities may be executed by skilled personnel only.

A0510COMPPRO

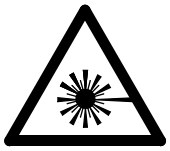
Brief operating personnel before beginning special operations and maintenance work, and appoint a person to supervise the activities.

In any work concerning the operation, conversion or adjustment of the COMPex*Pro* and its safety oriented devices or any work related to maintenance, inspection and repair, always observe the start up and shut down procedures set out in the instruction manual and the information on maintenance work.

Ensure that the maintenance area is adequately secured.



WARNING
Potential electrical hazards!
If the laser device is completely shut down for maintenance and repair work, it must be secured against inadvertent starting. Ensure that the electrical system is locked-out and tagged-out prior to servicing by locking the mains switch of the laser device with a padlock and tagging appropriate warning signs.



WARNING
Potential eye and skin burns!
If the laser device is completely shut down for maintenance and repair work, it must be secured against inadvertent starting. Ensure that the radiation system is locked-out and tagged-out prior to servicing by locking the mains switch of the laser device with a padlock and tagging appropriate warning signs.

CAUTION
Risk of gas leaks!
Switching off the laser device automatically closes the solenoid valves in the laser device's gas circuit. This interrupts the gas flow in the laser device, but does not evacuate the circuits in the laser device. Also, operating pressure remains in the external gas supply lines. For additional safety, close the corresponding external gas shut-off valves when locking out the laser device.

Always tighten any screwed connections that have been loosened during maintenance and repair.

Any safety devices removed for set up, maintenance or repair purposes must be refitted and checked immediately upon completion of the maintenance and repair work.

Ensure that all consumables and replacement parts are disposed of safely, with minimum environmental impact and in accordance with the valid national and local regulations for waste disposal.

3.2 Specific Safety Aspects

This section contains the following:

– Section 3.2.1 describes the physical and chemical hazards related to the laser device,

– Section 3.2.2 describes how operators or users of the laser device shall protect themselves against these hazards**,**

– Section 3.2.3 summarizes the constructive protective measures against these hazards.

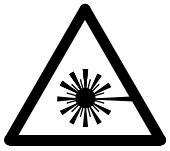
Lasers and laser systems are classified according to their relative hazards. These classifications can be found in the American National Standard for the Safe Use of Lasers (ANSI Z 136.1-2000), FDA 21 CFR 1040.10 and 1040.11, IEC-60825.

Within this classification, the COMPex*Pro* is a **Class IV (high power) laser device** when operated with open covers during servicing conditions, and must therefore be regarded as a potential hazard to the human operator. The laser beam must also be regarded as a potential fire hazard.

A Class IV laser system is not enclosed and, therefore, requires several safety precautions. Class IV is the most powerful (and potentially hazardous) category of lasers. Direct and scattered radiation from Class IV products are considered acute hazards to the eyes and skin. Precautions include eye and skin protection, remote interlocks and warning labels.

NOTE
The COMPex*Pro* is a class IV laser device. However, when connected to a laser unit (OEM device) with a fully encapsulated beam path, it becomes part of a Class I laser unit.

A Class I laser device is defined as a laser system which is supplied with a special enclosure which does not allow access to hazardous levels of laser light during normal operation. This class of laser does not require special precautions for eye safety during normal operations as long as the protective enclosure is in place.



WARNING
Risk of serious injury!
A COMPex*Pro* Class I laser system becomes a Class IV system when the enclosure is open.
The laser itself remains a class IV device.

A0510COMPPRO

3.2.1 Physical Hazards

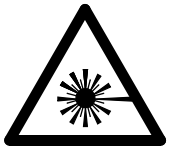
3.2.1.1 Laser Radiation Safety

Ultra-Violet Light

Laser radiation is emitted as a narrow beam of almost parallel rays, the intensity of which will remain high even at some distance of the laser. Although the radiation is nonionizing, damage can still occur to living tissue, if exposed for to long, as a result of heat produced during radiation absorption.

The radiation of an excimer laser lies outside the visible range. Possible wavelengths of the high intensity ultraviolet radiation are 157 nm, 193 nm, 248 nm, 308 nm or 351 nm.

When operating the laser at 157 nm, additional spontaneous and stimulated visible radiation occurs in the range between 635 nm and 755 nm.



WARNING
The laser beam is very dangerous to the eyes and skin!
The following are hazardous,
1. Direct radiation-light as it leaves the laser.
2. radiation-light which is reflected from a surface.
3. radiation-light, which is diffusely scattered from a surface.
Always wear appropriate safety goggles and protect your skin when there is a chance of exposure to radiation from the laser.
Never look into the laser beam.

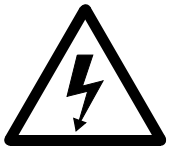
In general, the maximum permissible radiation exposure for the skin is several times greater than for the eye. Safety measures with regard to the radiation hazard are therefore mainly based on dangers for the eye.

A potential chemical hazard originates from interaction between the laser beam and an obstruction. The high irradiance could result in the liberation of hazardous fumes and gases. In addition, the heat generated is sufficient to ignite many materials.

Not only is the direct laser beam hazardous, but unchecked reflections of laser light also constitute a potential hazard. This risk is excluded if the laser beam is contained within a protective enclosure. Protective measures must be taken, therefore, when personnel are working in an open beam situation (use of beam shielding and beam dump).

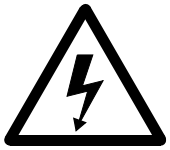
A0510COMPPRO

3.2.1.2 High Voltage / Electric Energy



WARNING
Electrical hazards!
High voltages exceeding the Safety Extra Low Voltage levels (SELV) of 42 VAC or 60 VDC introduce the potential hazard of electric shock and might cause serious injuries by passing electricity through the body.

High voltages of up to 32 kV are generated in the COMPex*Pro* laser device. As the equipment is provided with a protective housing, accidental contact with current-carrying conductors during normal operation is impossible. However, if an appropriate protective cover is removed, potentially lethal hazards exist in spite of the existence of the housing interlocks. With a protective cover removed, there is the risk of an electric shock whenever the mains supply is connected and the high voltage capacitors are charged. The capacitors in the laser device hold some joules at peaking voltages of up to 32 kV.



WARNING
Risk of electrocution!
Personnel should never open the laser device before the main power supply cable has been disconnected and the high voltage capacitors are completely discharged.

An electrical safety overview is given in Section 3.2.2.2 of this chapter (page 52), but reference should also be made to Section 3.2.3 (page 56) for an overall description of the system safeguards.

In addition to the above mentioned hazards, the HV switch used in the 1 kHz version (thyratron) generates ionizing radiation.

Radiation limit:	0.2 μSievert/h at 10 cm distance from laser device housing

This limit will not be exceeded if the COMPex*Pro* is operated in the specified manner.

A0510COMPPRO

3.2.1.3 Halogen Gases

WARNING!
Toxic gas hazard!
Careless handling of gas equipment can cause halogen gas to escape.
Avoid breathing in or skin contact with halogen gases.

The gas system of an excimer laser contains a mixture of 5% fluorine gas or 0.5% hydrogen chloride.

Halogens are extremely reactive and highly toxic gas which can cause severe chemical and thermal burns and in sufficient concentrations can cause death due to respiratory damage and pulmonary edema. They are characterized by an extremely stinging smell in very low concentrations. It is essential, therefore, that local safety regulations concerning the emission of chemical vapors must be strictly observed along with the recommendations made in this chapter and throughout this manual.

Depending upon the wavelength in which the laser is to be operated, the halogen is either fluorine or hydrogen chloride.

– Fluorine is in the form of a fluorine/helium mixture, ratio 95 % helium to 5 % fluorine. Fluorine is characterized by an extremely stinging smell in very low concentrations (0.1 ppm).

– Hydrogen chloride (HCl) is used as a premix gas with a ratio of < 0.5% HCl in the premix.

Both are diluted further with other gases in the laser. However, they are still present in sufficient quantities in the gas supply to cause serious injury if not correctly handled and used.

The attention of the user is drawn, therefore, to the following maximum permitted exposure limits for fluorine and hydrogen chlorine. The permitted periods of exposure time with respect to these limits will, however, depend upon local safety regulations.

The MAK (maximum acceptable concentration level) values according to the German publication:

"Technische Regel des Ausschuß für Gefahrstoffe des Bundesministeriums für Arbeit und Soziales"
(TRGS 900, October 2000)

are as follows:

F_2 Limit: 0.16 mg/m^3

HCl Limit: 8 mg/m^3

The possibility of over-pressure of the gas mixture containing fluorine or hydrogen chlorine creates potential hazards with the risk of leakage from the laser tube and gas pipes. Under normal operating conditions the overpressure is 2.5 bar (3.5 bar absolute). In the event of a leak occurring, the release of halogen gas constitutes the greatest hazard.

A0510COMPPRO

To remain below the MAK value of 0.16 mg/m^3 for fluorine even in a worse-case situation, unventilated rooms have to have an air volume of at least 100 m^3. When installaing the laser device in small rooms, make sure that there is an adequate air extraction system.

Further potential chemical hazards exist due to the formation of hydrofluoric or hydrochloric acid if the halogen gas comes into contact with water.

Hydrofluoric acid (in the form of KHF_2) and hydrochloric acid can also be formed in the halogen filters used in the system due to fluorine coming into contact with the hygroscopic components of the filter.

3.2.1.4 Ozone

The formation of ozone due to the interaction of ultra-violet light (193 nm and 157 nm) with oxygen constitutes a potential hazard.

The attention of the user is drawn, therefore, to the maximum permitted exposure limit for Ozone and the permitted periods of time in respect of this limits which depends on local and international safety regulations.

The MAK (maximum acceptable concentration level) values according to the German publication:

“Technische Regel des Ausschuß für Gefahrstoffe des Bundesministeriums für Arbeit und Soziales”
(TRGS 900, October 2000)

is as follows:

Ozone Limit: 0.2 mg/m^3

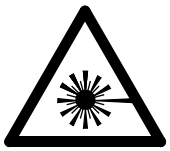
A0510COMPPRO

3.2.2 Personnel Safety

3.2.2.1 Laser Radiation Safety

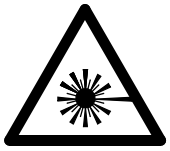
Ultra-violet Radiation Safety

An excimer laser emits high intensity pulsed ultraviolet radiation which constitutes a hazard to personnel during periods of operation and servicing.



WARNING
The laser beam is very dangerous to the eyes and skin!
The following are hazardous,
1. Direct radiation-light as it leaves the laser.
2. radiation-light which is reflected from a surface.
3. radiation-light, which is diffusely scattered from a surface.
Always wear appropriate safety goggles and protect your skin when there is a chance of exposure to radiation from the laser.
Never look into the laser beam.

If alignment or maintenance work on Class IV laser equipment is necessary, everyone in the laser area must wear appropriate protective goggles or other appropriate protective eyewear. The mandatory protective goggles provide protection against direct radiation, reflected radiation and standard radiation (normal operating conditions) within the respective wavelength range.



WARNING
Risk of serious eye injury!
Always wear protective goggles when there is a risk of exposure to radiation from the laser.
Before putting on the protective goggles, check them for any obvious defects. As the filter in the protective goggles provides protection for only a narrow band of wavelengths, make sure you are wearing the appropriate protective goggles for the laser device in question.
Check with your Laser Safety Officer or other safety personnel for guidance in selecting the appropriate goggles.

Contact a manufacturer of protective eyewear for information about appropriate protective eyewear. Specifications needed to select appropriate eyewear are: wavelength, power, beam diameter, repetition rate and max. pulse duration.

The ANSI (American National Standards Institute) standard for safe use of lasers requires that protective goggles which block the appropriate laser wavelength should be worn while operating or servicing class IV lasers. The goggles shall be clearly labeled with an optical density and the specified wavelength. To avoid confusion, these goggles should be kept separate from other safety glasses and personal protective equipment. Using the wrong type of goggles is dangerous. It can be worse to have improper eyewear and a false

A0510COMPPRO

sense of security than to have no eyewear and take precautions based on the absence of protection. Even if you're wearing protective goggles, never looked directly into the beam; intense laser radiation is capable of destroying the protective filter.

Visible Red Radiation

Operating the Laser at 157 nm (ultra-violet) causes additional spontaneous and stimulated emission of radiation in the range of 635 nm to 755 nm (visible red).

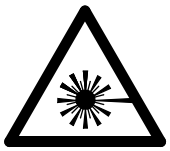
Optical Safety Guidelines

The following guidelines describe some of the actions necessary to avoid injury caused by the laser beam. Always follow these guidelines and take additional precautions if necessary.

- When eyewear is necessary, make sure it has the proper optical density for the laser wavelength.
- All other personnel in the vicinity of the laser should also be ordered to wear protective eyewear. Only qualified personnel should be permitted to operate the laser.
- Never intentionally look directly into any laser beam.
- Avoid indirect viewing of direct or reflected laser radiation. Specular reflections (from reflective surfaces) can be as dangerous as the direct laser beam. Do not view the beam through optical instruments unless the optics are designed to filter the laser wavelength.
- Precautions must be taken to ensure that there are no reflecting objects in the path of the laser beam.
- Do not deviate from standard operating procedures when working with class IV laser equipment.
- Use lasers only in approved applications and locations. Take adequate precautions to prevent unauthorized personnel from entering the area where a class IV laser is operating. Do not use lasers around untrained personnel who may injure themselves inadvertently. Ensure that all personnel in the area observed proper safety precautions.
- Do not assume the laser system is aligned. Misaligned optics can cause unintended exposure.
- Report all incidents of exposure to your supervisor.
- Warning signs indicating the laser enclosed area should be clearly displayed with an additional warning light outside the door.
- Local and national regulations governing the safe use of lasers should be adhered to all times.

A0510COMPPRO

Skin Safety Guidelines



WARNING
Potential skin burns!
Direct and reflected laser radiation can burn exposed skin.
Only use the laser in accordance with its designated use. Safety interlocks are only to be defeated by authorized personnel.

Although the skin can withstand a considerably higher radiation intensity than the eyes, tissue may be burned to a greater or lesser degree, depending on the radiation time and the irradiation intensity.

- Avoid contact between the skin and the beam, or specular reflections of the beam. Reflections of the beam may be as dangerous as the beam itself. Appropriate protective clothing should be worn to protect the skin whenever necessary.

Fire Safety Guidelines

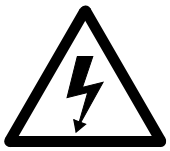
WARNING
Fire hazards!
Class IV lasers are, by definition, fire hazards.
The laser beam can cause flammable materials to ignite or explode.
Always keep a fire extinguisher in the laser area in case a fire occurs

Because of the high output power from the class IV laser, a wide range of materials can be set on fire. Therefore, when the beam path is open, appropriate fire prevention measures should be taken:

- Combustible materials may be ignited by the laser beam or by electrical components inside the laser system. Flammable items must be isolated from the laser beam and from the laser system.
- Paper (circuit diagrams, leaflets, or even posters on the wall), curtains that are not coated with fire retardant, wooden panels or similar materials can be easily set on fire by direct or reflected laser radiation.
- Only beam stops made of non flammable materials (not asbestos!) should be used.
- Many fluids and solvents (e.g. cleaning agents used for maintenance) are combustible. The intense beam of the laser or a spark from an internal switch can ignite vapors from these materials. Prevent the laser beam from contacting flammable materials used in the laser area.
- Move containers of flammable materials as far from the laser system as possible and shield them from the beam with opaque materials. Under no circumstances should these solutions and vapors be placed in the beam path or near the system.

A0510COMPPRO

3.2.2.2 Electrical Safety



WARNING
Electrical hazards!
If the laser device is completely shut down for maintenance and repair work, it must be secured against inadvertent starting. Ensure that the electrical system is locked-out and tagged-out prior to servicing by locking the key switch of the laser device and tagging appropriate warning signs.

High voltages of up to 32 kV are generated within the laser equipment. The following precautions should be observed:

- Local safety regulations must always be strictly complied with.
- Switch off the laser device immediately with an interlock switch or Emergency Off (EMO) switch in case of an emergency, i.e. to prevent injury or serious material damage, or if trouble occurs in the electrical system (see Section 3.2.3.2 on page 58). Contact after use of the interlock switch or EMO switch appropriate maintenance personnel (e.g. safety officer)
- Work on the electrical system or equipment may only be carried out by a skilled electrician himself or by specially instructed personnel under the control and supervision of such electrician and in accordance with the applicable electrical engineering rules.
- The mains supply line (power cord) shall only be installed or exchanged by a skilled electrician working according to appropriate electrical engineering rules and regulations.
- Fault finding and troubleshooting in high voltage circuits shall only be performed by trained personnel.
- Necessary work on live parts and elements must be carried out only in the presence of a second person who can cut off the power supply in case of danger by actuating the emergency shut off or key switch.
  Secure the working area with a red and white safety chain and a warning sign.
  Use insulated tools only.
- If provided for in the regulations, the power supply to parts of the COMPex*Pro* laser device on which inspection, maintenance and repair work is to be carried out must be cut off.
- Before starting any work, check the de-energized parts for the presence of power and ground or short circuit them in addition to insulating adjacent live parts and elements.
- Use only original fuses with the specified current rating.
- The electrical equipment of the COMPex*Pro* laser device is to be inspected and checked at regular intervals. Defects such as loose connections or scorched cables must be rectified immediately.

A0510COMPPRO

3.2.2.3 Gas Safety

WARNING!
Toxic hazards!
The gas system of an excimer laser contains a mixture of up to 5 % fluorine or 0.5 % hydrogen chloride.
Aviod inhalation of or skin contact with hydrogen gases.

The properties of compressed gases, such as pressure, diffusibility, make the handling of compressed gases hazardous. Laser gas mixtures invariably contain components which are corrosive, toxic and oxidizing. Therefore, extreme care must be taken when handling these mixtures.

As a general guide to safe working practices, the following precautions should be observed when working with gas equipment. Always follow these guidelines and take additional precautions if necessary.

- Gas protective equipment, such as masks, must be available at the entrance to the area where the laser is located.
  Ensure that a protective mask with a protective gas filter, or a complete breathing apparatus set, is placed in a clearly displayed and accessible part of the operating area.
- It is recommended that personnel work in pairs and within sight and sound of each other, although not necessarily in the same working area. Only trained and competent personnel should be permitted to handle halogen gas cylinders and regulators.
- Any equipment to be used for halogen gas mixture servicing should be thoroughly cleaned, degreased and dried before use, then treated with increasing concentrations of halogen gas so that any impurities can be burned off without the risk of the equipment catching fire.
- Any equipment that has contained halogen must be thoroughly purged with helium or argon and evacuated prior to opening or refilling.
- Due to the possibility of over-pressure of the gas mixture containing halogens, potential hazards exist due to the risk of leakage of the laser tube and gas pipes. The most vulnerable part is the window. Under normal operating conditions the pressure is 3.8 bar. The equipment must be used such that the beam exit is not directed at personnel. In the event of a leak occurring, the release of halogen gas constitutes the greatest hazard.
- The COMPex*Pro* laser has an externally connected vacuum pump. This means that there is the potential risk of a gas leak when evacuating the gas mixture from the excimer laser. To reduce the risk of a hazardous concentration of halogen gas, a halogen sensor and an extraction system should, therefore, be installed in the area of the vacuum pump.

- Avoid repeated bending and excessive vibration of gas piping and equipment as this can result in flaking of the protective halide film and rupturing of the metal. This could lead to the occurrence of a fluorine metal fire. Flaking of the protective film can also cause dust to foul the valves.
- All areas containing pressurized halogen gas mixtures should be inspected for leaks periodically (weekly). In the event of a leak occurring, the release of halogen gas constitutes the greatest hazard.
- All leaks should be repaired immediately, but not while the system contains halogen.

  With fluorine: ammonia vapor expelled from a squeeze bottle containing ammonium hydroxide may be used to detect leaks at suspected points.
  Filter paper moistened with potassium iodide solution is a very sensitive means of detecting fluorine in concentrations as low as approximately 25 parts per million. The potassium iodide paper should be held with the aid of 18 to 24 inch long tongs or forceps, and will darken and turn black when fluorine is present. Fluorine odor is sufficiently strong to be detectable in very low concentrations (at 0.14 parts per million). Fluorine will also fume readily in air.
- Adequate ventilation is essential. See Section 4.2.5 on page 83 for the specifications of the required air flow. There should be a minimum of at least 10 air changes per hour for enclosed spaces.

WARNING
Toxic hazard!
Ensure that the laser is ventilated into an appropriate exhaust. Make sure that the exhaust of the laser is not connected to the duct system of systems used for the processing of breathing air (e. g. air conditioning or ventilating systems).

- Ozone can be generated by ultra-violet radiation (in particular with ArF at 193 nm). This gas should be removed with a proper air exhaust or by flushing the beam path with Nitrogen or Argon.
- Always wear protective gloves when changing halogen filters as they are hygroscopic and contain oxidizing agents.
- Gas cylinder valves should be closed except while filling the laser, or when running the laser in the constant energy mode (EGY Const.).
- As the premix gas contains halogen, a needle valve or cut-off valve should be installed in the fluorine premix gas line. The additional valve is to be located near the gas cylinder to protect the gas line and pressure regulator against corrosion and provide additional gas protection. Do not solely rely on the main gas cylinder valve to provide adequate protection.

A0510COMPPRO

- The pressure regulator, situated between the external gas cylinder and the laser, should be checked regularly. The maximum permitted value while cylinders are opened is 5.0 bar (abs.) respectively 7.0 bar (abs.) to operate the halogen source's pilot valve.

3.2.2.4 Pressure Vessel Safety

Gas pressures of up to 3.8 bar (abs.) are permitted in the laser tube. If pressure rises above that, a built-in safety valve releases the overpressure via the halogen filter into the exhaust. The following precautions should be observed:

- The laser should only be operated with the housing closed.
- In accordance with the European Pressure Equipment Directive, Lambda Physik recommends to have the laser tube checked by a specialist every five years. Call Lambda Physik Service for further information.

3.2.2.5 Seismic Protection

For installations in areas that are susceptible to seismic activity, the end user is responsible for appropriately securing the laser device within their facility or the OEM is responsible if the laser device should be installed within an OEM device, alternatively. For the exact configuration of the protective devices, local regulatory requirements are to be followed and the site vulnerability of the facility or OEM device (e.g. soil conditions and design) is to be taken into account. Provision is to be made for the following:

- Anchors to prevent movement or overturning of the laser device during a seismic event.
- Suitable strain relief devices for all supply lines to control the risks through leakage or escape of gases, liquids and electricity etc. during a seismic event.

A0510COMPPRO

3.2.3 Constructive Safety Features

The laser device is equipped with the following constructional safety features:

3.2.3.1 Radiation Safety Features

- Appropriate Class IV label affixed to laser device enclosure (see Section 3.3.1 of this manual).
- All parts of the laser where laser radiation may possibly escape are marked with the appropriate adhesive danger signs (according to IEC 60825-1).
- A white Laser ON warning light (see Figure 25, A) is located in a prominent position on top of the laser device near to the beam exit aperture. This warning light illuminates when the laser can emit radiation. Emission of radiation can be recognized by an inherent clicking noise, the frequency of which increases as the repetition rate increases.

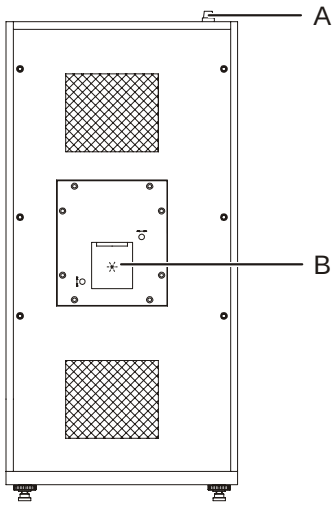


Figure 25: *Laser radiation warning light and shutter*

- Each beam exit from the laser housing can be closed by a manually operated beam shutter (see Figure 25, B).

A0510COMPPRO

- COMPex*Pro* laser devices are provided with a connector marked ”Remote” located on the connection side of the laser housing (see Figure 26, A). This enables connection to external electrical circuits for a warning light and one or more interlock switches (the appropriate plug is included in the service box).

  The warning light signals that the laser is operating and, therefore, warns of the risk of laser radiation.

  The interlock switch shuts down the laser externally, for instance if a door connected with the switch is opened.

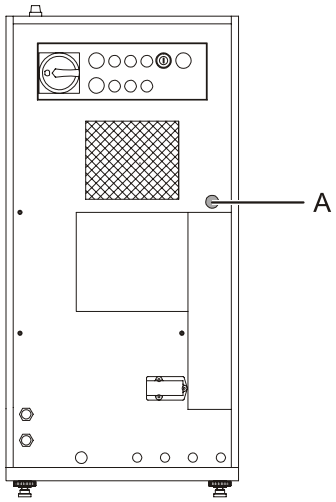


Figure 26: *Remote connection*

NOTE
The Remote Interlock only switches off the high voltage. After closing the door switch, the laser can be restarted. To prevent the laser from being simply restarted after activation of a door contact, the contact has to be integrated in an external EMERGENCY OFF circuit that interrupts the mains voltage supply to the laser device. The specifications of the Remote Interlock are indicated in Section 4.3.8.2 on page 95.

- The basic Module is monitored by a watchdog. The COMPex*Pro* immediately indicates if this module has failed testing.
- The service panel of the laser is equipped with an interlock which will shut off high voltage if the laser is opened during operation.

3.2.3.2 Electrical Safety Features

The following safety features protect the user from the potentially lethal hazards associated with high voltage power sources:

- The “Remote” connector on the connection panel of the HV power supply module is configured so that the contacts have to be closed to enable the HV power supply. If the contacts are opened during laser operation, the HV power supply will be immediately shut down.
- Opening a housing cover panel for service triggers a housing cover interlock switch that shuts off the high voltage and, consequently, the laser radiation. This does not apply for the mirror access panels, which can be removed to service the optics of the COMPex*Pro*.
- The main switch is designed to enable the insertion of a lockout device that corresponds with OSHA 29 CFR 1910.147 when the switch is set to OFF. This ensures that the laser device can be locked out to perform servicing or maintenance.
- All potentially lethal voltages are contained in fully protected and grounded enclosures.
- The Power Module shielding encloses the HV parts of the laser to protect the surroundings against ionizing radiation and electro-magnetic interference (limits, see Section 3.2.1.2 on page 46). A proper closed laser housing completely shields the surroundings from the ionizing radiation. The emission of ionizing radiation has been checked by the German Physikalisch-Technische Bundesanstalt (PTB). No radiation beyond background radiation was detected with covers closed.
  Opening the Power Module shielding discharges the capacitors by a safety switch release.
- High voltage warning labels are prominently displayed on all three high voltage modules: the high voltage power supply, the gas processor power supply and the high voltage circuitry.
- For service the capacitors can be discharged through a shortcut plate to ground.
- All AC power wiring is UL-recognized or VDE-recognized and rated at 600 V. Black or brown is used for line phases, blue or white is used for neutral and green or yellow-green is used for ground (depending on the power supply version).
- A yellow-green grounding conductor is included in every AC power module. All power connectors have grounding pins that make first and break last.
- All ground conductors are equipped with a ring lug and external tooth lockwasher.
- Fuses are used to provide branch circuit protection against low level faults.

A0510COMPPRO

- AC power and signal lines are never combined in the same connector.
- Fast acting magnetic circuit breakers with at least 10 kA interrupting capacity, a lockable disconnect means and an emergency-off function are supplied with the main switch.
- All external low voltage (24 V) lines conform to the VDE 0551 safety standard.

3.2.3.3 Pressure and Gas Handling Safety Features

The Lambda Physik Excimer Laser incorporates the following pressure and gas handling features:

- The pressure chamber is designed in accordance with the European “Pressure Equipment Directive” (97/23/EEC). Every pressure vessel is tested according to the European “Pressure Equipment Directive” (97/23/EEC).
- Gas valves are electrically operated.
- The main housing is fully interlocked.
- All gas fittings are 6 mm Gyrolok.
- A powerful ventilation system causes continuous underpressure in the tube chamber during laser operation. This prevents toxic gas from escaping into the ambient air in case of a leak.
- The exhaust enclosure is designed to ensure ventilation of all components.

3.2.3.4 Fire Safety Features

The fire safety features designed into Lambda lasers eliminate the use of materials which are combustible or produce toxic vapors as well as preventing flames from spreading or burning materials from dripping. The design incorporates the following specific fire safety features:

- No easily inflammable materials touch potential sources of ignition or hot surfaces.
- Except for electrical wire insulation polyvinyl chloride (PVC) is not used.
- No ventilation holes in fire break enclosures are in excess of 5 mm (0.20") in diameter. Hole arrays are used as required.
- Material meeting or exceeding UL 94-V1 is used.

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3.2.3.5 Mechanical Safety Features

Mechanical safety design provides protection against any hazards which could cause physical injury or burns. Specific mechanical safety features are listed below:

- Exposed corners are radiused.
- Air fans have grill guards with less than 6.4 mm (0.25 in).
- No high temperature components are accessible to touch.
- The laser center of gravity is centrally located within the enclosure to minimize tipping hazard.
- Threaded holes are provided in the base of the housing to allow suitable seismic anchorage of the laser device.

3.2.3.6 General Safety Features

The COMPex*Pro* incorporates the following general safety features:

- Key-switch controlled laser operation.
  The laser device can only be switched on with the key-switch (see Figure 27, A). This prevents inadvertent or unauthorized starting of the laser. It cannot be operated with the key in the OFF position and the key cannot be removed in the ON position.

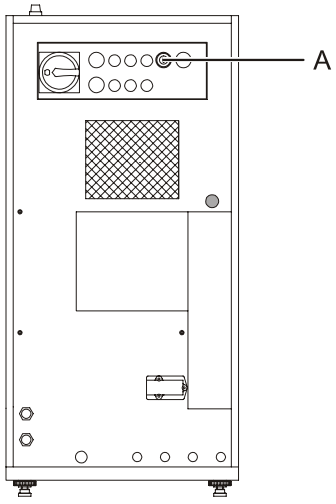


Figure 27: *Key switch*

A0510COMPPRO

- Warning lights:
  - Laser radiation warning light (see Figure 25, A on page 56) illuminates (white) when laser radiation is being emitted or can be emitted.
  - Mains voltage warning light (see Figure 28, A) illuminates (green) when mains voltage is applied to the laser device.
  - Control voltage warning light (see Figure 28, B) illuminates when the control voltage (24 V) is switched on.

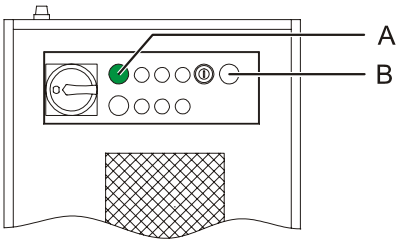


Figure 28: *Location of voltage warning lights*

- No polychlorinated biphenyl (PCB) is used.
- No asbestos is used.

3.3 Labels

This section describes the location and purpose of the safety-relevant labels attached to the COMPex*Pro* excimer laser device.

Ensure that all warning labels are affixed to the laser device according to the plans given in this section.

WARNING
Risk of injury!
Misuse or improper handling of the laser device can cause serious or, in certain situations, even lethal injuries.
Never put the COMPex*Pro* into operation if the labeling is incomplete. Immediately replace missing labels or inform Lambda Physik of their absence.

NOTE
To simplify the ordering of labels, the appropriate Lamdba Physik part number is indicated behind the position number of the corresponding label.

A0510COMPPRO

3.3.1 Labels on Outside of Laser Device

3.3.1.1 Beam Exit Side

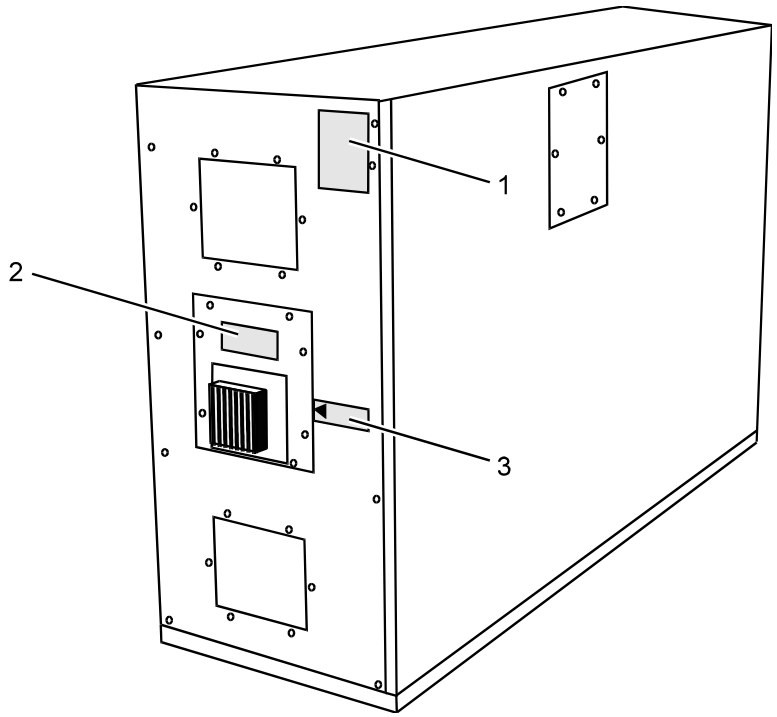
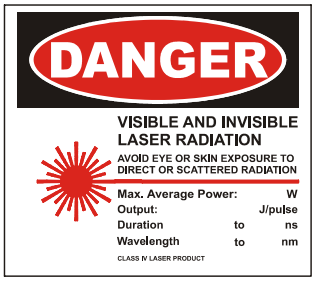


Figure 29: *Labels on beam exit side*

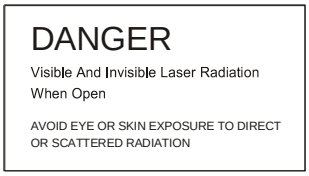
A0510COMPPRO

Pos. 1 (# 901032)
Warning label according to CDRH. This contains a laser radiation warning and device-specific laser data. The information indicated on this label is important for the choice of laser protective eyewear.

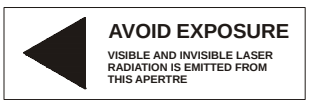

DANGER
VISIBLE AND INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION
Max. Average Power: W
Output: J/pulse
Duration to ns
Wavelength to nm
CLASS IV LASER PRODUCT

Model	Power [W]	Energy [J]	Duration [ns]	Wavelength [nm]
COMPex*Pro* 102	20	0.6	10 - 50	193 - 351
COMPex*Pro* 110	50	0.6	10 - 50	193 - 351
COMPex*Pro* 120	50	0.4	10 - 50	193 - 351
COMPex*Pro* 201	20	1	10 - 50	193 - 351
COMPex*Pro* 205	50	1	10 - 50	193 - 351
COMPex*Pro* F_2	20	0.4	10 - 50	157 - 800

Pos. 2 (# 904025):
Label warning of exposure to laser radiation when the mirror access panel is removed.



Pos. 2 (# 901031):
Beam output safety sign. Label indicating that laser radiation is emitted from the aperture to the left of the label.



A0510COMPPRO

3.3.1.2 Connection Side

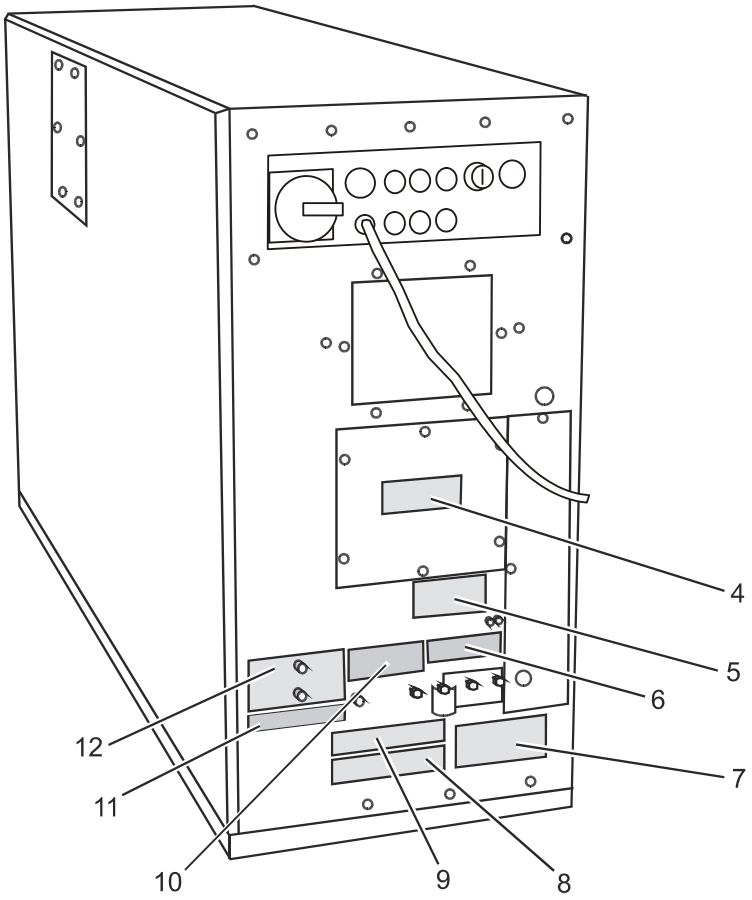
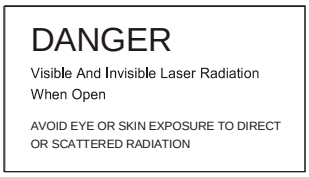


Figure 30: *Labels on connection side*

Pos. 4 (# 904025):
Label warning of exposure to laser radiation when the mirror access panel is removed.



A0510COMPPRO

Pos. 5 (# 90512101):
This complying with IEC 60825 that provides safety instructions for when the laser device is being operated with a handheld keypad or remote computer at distances at more than 2 m from the laser device.

ATTENTION

IF CONTROLLER AND LASER ARE SEPARATED MORE THAN 2 METERS, ALSO THE CONTROLLER HAS TO BE EQUIPPED WITH APPROPRIATE WARNING LABELS AND EMISSION INDICATOR (SEE MANUAL)

Pos. 6 (# 90103401):
Label to certify that the laser complies with FDA radiation performance standards.

This product complies with FDA radiation performance standards 21 CFR Chapter 1, Subchapter J

Pos. 7 (# 90483301):
Label warning of the presence of toxic and corrosive gases.

TOXIC AND CORROSIVE GASES

Pos. 8 (# 905384):
Label warning that gas connections must be sealed when opened.

GASANSCHLÜSSE UND GAS-ZULEITUNGEN SIND NACH DEM TRENNEN ODER BEI NICHTBENUTZUNG ZU VER-SCHLIESSEN	GASINLETS AND SUPPLY OUTLETS MUST BE BLAN-KED OFF AFTER DISCON-NECTING OR IF NOT USED

Pos. 9 (# 906446):
(Fluorine version only) Label stipulating that no gas mixture other than fluorine gas mixtures shall be be used.

Nur Fluor-Gasgemische verwenden!

Only for Fluorine-Gas Mixtures!

A0510COMPPRO

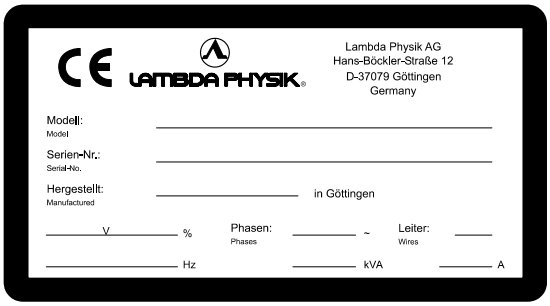
Pos. 10 (# 905910):
Label indicating that the laser device is protected by one or more patents.

THIS LASER OR ITS COMPONENTS ARE
PROTECTED BY ONE OR MORE PATENTS.
OTHER PATENTS ARE PENDING.

Pos. 11 :
Label showing electrical frequency for the main supply, where XX is replaced by the value of the frequency.

Laser is switched for XX Hz

Pos. 12 (# 90574301):
Identification plate for the laser device indicating model, serial number, year of manufacture and principal technical data (emission range, max. pulse energy, electrical connection of HV power supply module).



A0510COMPPRO

3.3.2 Labels Inside Laser Device

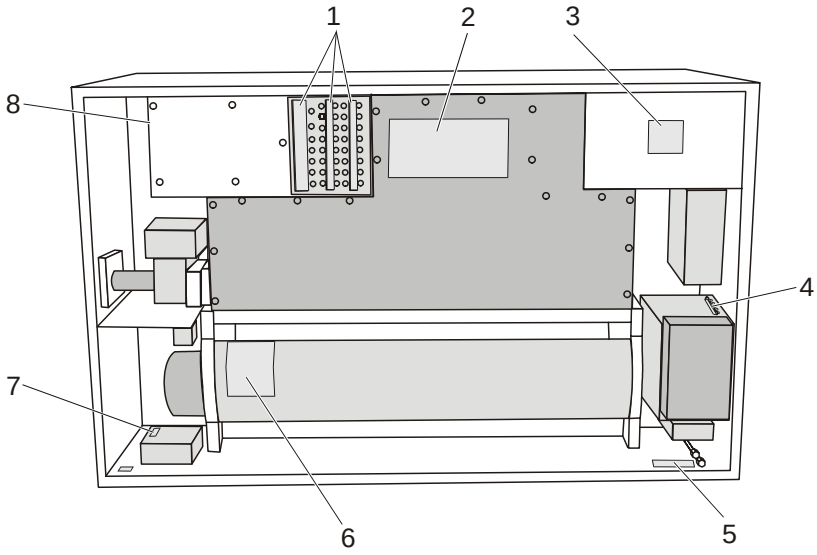
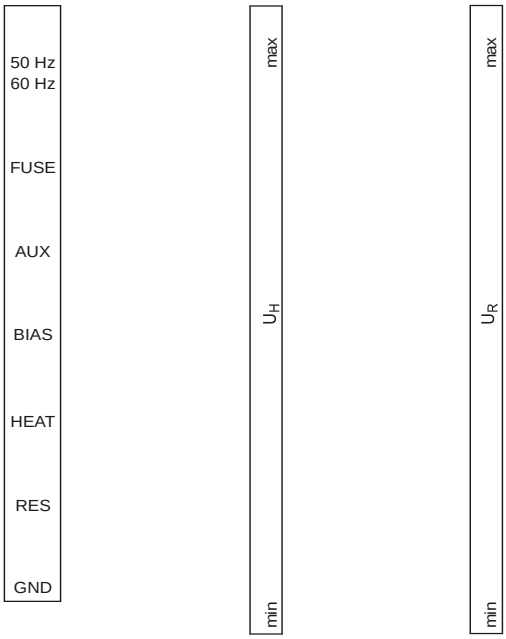


Figure 31: *Labels inside*

Pos. 1:
Labels at the thyratron adjustment panel.

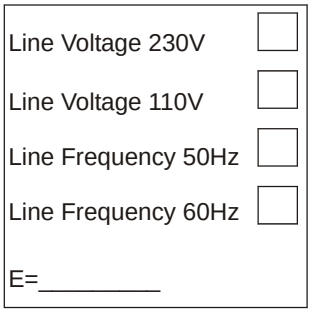


A0510COMPPRO

Pos. 2 (# 900837):
Label warning of risk of electrocution if the high voltage circuitry behind the panel to which the label is attached is accessed without taking the correct precautions. The panel to which the label is attached shall only ever be removed by correspondingly qualified and authorized personnel.

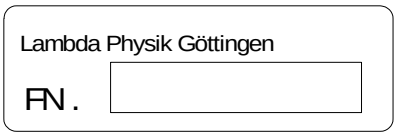
LEBENSGEFAHR!
Nur Personal, vollständig vertraut mit den Vorsichtsmaßnahmen für Arbeiten an Hochspannungsgeräten darf Arbeiten am Gerät ausführen.
Vor jedem Service ist stets das Handbuch zu lesen.
Alle Anweisungen zur dauerhaften Erdung, sowie Prüfung auf Abwesenheit der Hochspannung sind genau und jederzeit zu befolgen.
Only Personnel fully conversant with safety measures for working with High Voltage equipment shall perform work at this equipment.
Every time before service it is mandatory to read the Manual.
All instructions for positive Grounding and Check for Absence of High Voltage have to be followed meticuously and at any time.
DANGER TO LIFE!

Pos. 3 (# 903070):
Label showing the electrical frequency and voltage to be provided by the mains power supply.



Pos. 4 (# 905221):
Label indicating the power supply unit's fuses.

Pos. 5 (# 900663):
Fabrication number of the laser device.



A0510COMPPRO

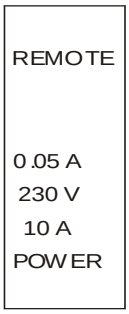
Pos. 6 (# 904489):
Laser tube identification label.

LAMBDA PHYSIK			
SERIEN-NR.: SERIAL-NO.:	SIEHE SCHLAGZAHL SEE ENGRAVED NUMBER		
BAUJAHR: MANUFACTION YEAR:			
MAX. BETRIEBSDRUCK: MAX. OPERATION PRESSURE:		BAR	
MAX. BETRIEBSTEMPERATUR: MAX.OPERATION TEMPERATURE:		°C	
MIN. BETRIEBSTEMPERATUR: MIN.OPERATION TEMPERATURE:		°C	
INHALT: VOLUME:		LITER LITRE	
GAS PROZESSOR: GAS PROCESSOR:		KV	
ANODE: ANODE:	P:	NO:	
KATHODE: CATHODE:	P:	NO:	
ELEKTRODEN-ABSTAND: ELECTRODE GAP:		MM	

Pos. 5 (# 900641):
Label warning of the risk of electrical shock or even electrocution if the module(s) and/or component(s) situated near to or behind the cover to which the label is affixed are touched or treated improperly.
Only correspondingly qualified and authorized personnel shall open and work on the indicated module(s) and/or component(s)!

A0510COMPPRO

Pos. 5 (# 380289):
Label naming the (upper) remote plug and describing the (lower) power supply plug.



A0510COMPPRO

4 SPECIFICATIONS, REQUIREMENTS AND ACCESSORIES

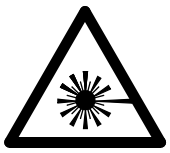
This section contains the specifications required to integrate the COMPex*Pro* into a laser assembly or laser unit.

Due to Lambda Physik's policy of continuous optimization of their laser devices, the data contained in this chapter is subject to variation.

Should information on separate sheets (e.g. laser data sheets) attached to or provided together with this Instruction Manual contradict the information in this chapter, the information on the separate data sheets has priority.

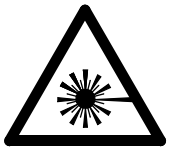
4.1 Laser Specifications

Excimer lasers emit extremely intensive pulsed radiation that represents a potential hazard to personnel during operation and maintenance.



WARNUNG
Risk of serious eye injury through laser radiation!
Always wear suitable eye protection when there is the risk of exposure to laser radiation.

Whenever operation, maintenance or adjustment work is being performed on a open class IV laser system, all persons in the vicinity of the laser shall wear laser protective goggles or other suitable eye protection. The necessary protective goggles have to protect against direct, reflected and scattered radiation (during normal operation).



WARNUNG
Risk of skin injury!
Direct and reflected laser radiation can cause burns to unprotected skin. Only use the laser in accordance with its intended purpose. Safety interlocks shall only be bridged by authorized persons.

Avoid skin contact with direct or reflected laser radiation. Reflected laser radiation can be as equally hazardous as the beam itself. Where necessary, wear suitable protective clothing to protect the skin.

4.1.1 COMPex*Pro* 100 Series

CDRH class (laser classification)	IV
Power	≤ 30 W
Pulse shape (temp.)	≥ 10 ns
Pulse to pulse stability	≤ 3 % for 1 Sigma

Characteristic	Type	ArF	KrF	XeCl	XeF	Unit
Wavelength		193	248	308	351	nm
Max. pulse energy[a]	COMPex*Pro* 102 (F-Version)	200	400	--	150	mJ
	COMPex*Pro* 102 (Cl-Version)	--	--	200	--	mJ
	COMPex*Pro* 110 (F-Version)	200	400	--	150	mJ
	COMPex*Pro* 110 (Cl-Version)	--	--	200	--	mJ
Max. repetition rate	COMPex*Pro* 102	20	20	20	20	Hz
	COMPex*Pro* 110	100	100	100	100	Hz
Max. average power[b]	COMPex*Pro* 102 (F-Version)	4	6	--	3	W
	COMPex*Pro* 102 (Cl-Version)	--	--	4	--	W
	COMPex*Pro* 110 (F-Version)	12	30	--	12	W
	COMPex*Pro* 110 (Cl-Version)	--	--	16	--	W
Pulse duration (nominal)	COMPex*Pro* 100 Serie	20	25	20	25	ns FWHM
Beam dimensions[c]	COMPex*Pro* 100 Serie	24 x 5-10	24 x 5-10	24 x 5-10	24 x 5-10	mm^2 (v x h)
Beam divergence[c]	COMPex*Pro* 100 Serie	3 x 1	3 x 1	3 x 1	3 x 1	mrad (v x h)

a. measured at low repetition rate (5 Hz)
b. average value, measured at max. repetition rate
c. typical value, FWHM (Full Width Half Maximum)

A0510COMPPRO

4.1.2 COMPex*Pro* 200 Series

CDRH class (laser classification)	IV
Power	≤ 30 W
Pulse shape (temp.)	≥ 10 ns
Pulse to pulse stability	≤ 3 % for 1 Sigma

Characteristic	Type	ArF	KrF	XeCl	XeF	Unit
Wavelength		193	248	308	351	nm
Max. pulse energy[a]	COMPex*Pro* 201 (F-Version)	400	700	--	300	mJ
	COMPex*Pro* 201 (Cl-Version)	--	--	400	--	mJ
	COMPex*Pro* 205 (F-Version)	400	700	--	300	mJ
	COMPex*Pro* 205 (Cl-Version)	--	--	400	--	mJ
Max. repetition rate	COMPex*Pro* 201	10	10	10	10	Hz
	COMPex*Pro* 205	50	50	50	50	Hz
Max. average power[b]	COMPex*Pro* 201 (F-Version)	4	5	--	3	W
	COMPex*Pro* 201 (Cl-Version)	--	--	3,5	--	W
	COMPex*Pro* 205 (F-Version)	15	30	--	15	W
	COMPex*Pro* 205 (Cl-Version)	--	--	20	--	W
Pulse duration (nominal)	COMPex*Pro* 200 Serie	20	25	25	20	ns FWHM
Beam dimensions[c]	COMPex*Pro* 200 Serie	24 x 6-12	24 x 6-12	24 x 6-12	24 x 6-12	mm^2 (v x h)
Beam divergence[c]	COMPex*Pro* 200 Serie	3 x 1	3 x 1	3 x 1	3 x 1	mrad (v x h)

a. measured at low repetition rate (5 Hz)
b. average value, measured at max. repetition rate
c. typical value, FWHM (Full Width Half Maximum)

A0510COMPPRO

4.1.3 COMPex*Pro* F_2 Series

CDRH class (laser classification)	IV
Power	≤ 30 W
Pulse shape (temp.)	≥ 10 ns

Characteristic	**F_2**	**Unit**
Wavelength	157	nm
Max. pulse energy[a]	10	mJ
Max. repetition rate	50	Hz
Max. average power[b]	0,5	W
Beam dimensions[c]	(19 ± 4) x (7 ± 2)	mm^2 (v x h)
Beam divergence[c]	6 x 2	mrad (v x h)

a. measured at low repetition rate (5 Hz)
b. average value, measured at max. repetition rate
c. typical value, FWHM (Full Width Half Maximum)

A0510COMPPRO

4.2 Facilities

4.2.1 Environmental Conditions

This section indicates the recommended environmental conditions for the transport, storage and operation of the COMPex*Pro* laser device.

4.2.1.1 Transport and Storage

NOTE
The indicated temperature range only applies when all cooling water has been bled from the system.

Temperature range	-20 to +50 °Celsius
Max. temperature gradient	5 °C/h
Ambient air pressure	650 to 1070 mbar
Max. pressure gradient	75 mbar/h
Humidity	less than 70 % RH
Max. acceleration during transport	1 G

4.2.1.2 Operation

Temperature range	5 to 30 °C
Max. temp gradient	5 °C/h
Altitude	0 to 2000 m above sea level
Max. pressure gradient	75 mbar/h
Humidity	30 to 70 % RH
Cleanroom class	10,000

CAUTION
Risk of contaminating optical components!
The ambient air is to be free of dust, oil, organic particles, corroding substances and photochemically decompositable or depositable compounds. Protect the beam path and the laser optics with a purgeable shield at critical environmental conditions.
Please contact Lambda Physik for more information.

4.2.2 Gases

Excimer Laser Gas

The active medium in an excimer laser is a mixture of a rare gas, a halogen gas and a buffer gas. The required gas mixture depends on the type of laser and the wavelength at which the laser is to be operated.

As standard, the COMPex*Pro* is optimized for fluorine operation at the wavelengths 193 nm, 248 nm and 351 nm. Optionally available is a multigas laser tube which additionally enables XeCl operation at a wavelength of 308 nm. For operation at 157 nm, a special F_2 version of the COMPex*Pro* laser device is required.

The required gas mixtures for the available types of laser and possible wavelengths are shown in the following table.

Type	Wavelength	Gas Mixture
COMPex*Pro* 100 series	351 nm	F2 in He / Xe / Ne
	308 nm	HCl, H2 in He / Xe / Ne
	248 nm	F2 in He / Kr / Ne
	193 nm	F2 in He / Ar / Ne / He
COMPex*Pro* 200 series	351 nm	F2 in He / Xe / Ne / He
	308 nm	HCl, H2 in He / Xe / Ne
	248 nm	F2 in He / Kr / Ne
	193 nm	F2 in He / Ar / Ne
COMPex*Pro* F_2	157 nm	F2 in He / He

Additional Operating Gases

In addition to the gases required for the excimer laser gas mixture, further gases are required to operate the laser device:

– Helium (He) is required to purge the laser tube and the gas lines.

– Neon (Ne) is required to ensure the safe transport and storage of the laser device.

– Nitrogen (N2) is required to purge the beam path and optics modules of the COMPex*Pro* F_2.

A0510COMPPRO

External Excimer Laser Gas Supply

The laser device's gas supply system allows connection to either separate gas cylinders or a single premix gas cylinder.

When supplied from separate gas cylinders, the necessary quantity of each gas will automatically be taken from the appropriate gas cylinder during the automated gas filling procedure, The gases are mixed inside the laser tube. No additional external equipment is required to proportion or mix the gases ready for use.

Operation with a premix gas cylinder is recommended for low duty cycle applications that consistently use the same laser wavelength. In this case one cylinder of premix excimer laser gas and separate cylnders with the necessary additional operating gases (e.g. helium and nitrogen) are required.

Section 4.2.2.1 specifies the individual laser gases required to supply the laser device from separate gas cylinders.

Section 4.2.2.2 specifies the exact quantity of each of the individual gases that are required to provide the optimum gas mixture for the desired wavelength. The information in this section can be used as a guide for ordering an appropriate premix gas.

Ensure that the appropriate gases are available for the wavelength that the laser is to be operated at.

NOTE
A) Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas supply system, pressures below 20 bar (abs.) may be critical.
B) COHERENT LAMBDA PHYSIK recommends using halogen / premix gas cylinders for max. one year and all other gas cylinders for max. two years.
C) The gas connections are described in Section 4.3.4 on page 89.

Halogen Source

As an option, Lambda Physik offers a halogen source that can be used instead of a halogen gas cylinder. The halogen source is the controlled by the laser device.

Halogen Filter

A halogen filter is built into the laser and will fully absorb all of the halogen exhausted during the filling procedures. No toxic gases will leave the laser device. The halogen filter filling ratio is monitored by the laser control software. The filter should be exchanged after up to 30 gas fills or on a yearly basis, whichever comes first.

A0510COMPPRO

4.2.2.1 Single Gases

Fluorine (F_2 in He) for COMPex*Pro* 102 / 110 / 201 / 205[a]

Type of gas	0.5 % F2 in 95 % He
Purity of Helium	99.995 % or higher
Purity of Fluorine	for Excimer laser, HF free
Pressure regulator	3.5 to 5.0 bar (abs.)
Flow	0.3 to 3.0 l/s
Recommended cylinder size	10 l, 150 bar (2100 psi)

a. Not required when optional fluorine source is used

Fluorine (F_2 in He) for COMPex*Pro* F_2[a]

Type of gas	0.5 % F2 in 95 % He
Purity of Helium	99.995 % or higher
Purity of Fluorine	for Excimer laser, HF free
Pressure regulator	4.4 to 5.2 bar (abs.)
Flow	0.3 to 3.0 l/s
Recommended cylinder size	10 l, 150 bar (2100 psi)

a. Not required when optional fluorine source is used

Hydrogen chloride (HCl, H_2 in He)

Type of gas	5 % HCl and 1 % H2 in He
Purity	99.995 % or higher
Pressure regulator	3.5 to 5.0 bar (abs.)
Flow	0.3 to 3.0 l/s
Recommended cylinder size	10 l, 100 bar (1400 psi)

Argon (Ar)

Type of gas	Ar
Purity	99.995 % or higher
Pressure regulator	3.5 to 5.0 bar (abs.)
Flows	0.8 to 3.0 l/s
Recommended cylinder size	50 l, 200 bar (2800 psi)

A0510COMPPRO

Krypton (Kr)

Type of gas	Kr
Purity	99.99 % or higher
Pressure regulator	3.5 to 5.0 bar (abs.)
Flow	0.8 to 3.0 l/s
Recommended cylinder size	10 l, 100 bar (1400 psi)

Xenon (Xe)

Type of gas	Xe
Purity	99.99 % or higher
Pressure regulator	3.5 to 5.0 bar (abs.)
Flow	0.8 to 3.0 l/s
Recommended cylinder size	2.5 l, 50 bar (700 psi)

Neon (Ne)

Type of gas	Ne
Purity	99.995 % or higher
Pressure regulator	3.5 to 5.0 bar (abs.) with fluorine cylinder or 6.5 to 7.0 bar (abs.) for fluorine source
Flow	0.8 to 3.0 l/s
Recommended cylinder size	200 l, 200 bar (2800 psi)

Helium (He), flushing gas for laser tube

Type of gas	He
Purity	99.995 %
Pressure regulator	3.5 to 5.0 bar (abs.) with fluorine cylinder or 6.5 to 7.0 bar (abs.) for fluorine source
Flow	0.8 l/s to 3.0 l/s
Recommended cylinder size	200 l, 200 bar (2800 psi)

Nitrogen (N2), purge gas for beam path[a]

Type of gas	N2
Purity	99.999 % (boil off quality)
Pressure regulator	2.0 to 2.5 bar (abs.) with fluorine cylinder or 6.5 to 7.0 bar (abs.) for fluorine source
Flow	1.0 to 12.0 l/s
Recommended cylinder size	50 l, 200 bar (2800 psi)

a. Only for COMPex *Pro* F_2

A0510COMPPRO

4.2.2.2 Gas Mixtures

The following table provides an overview of the excimer las gas mixtures used. The gases are listed in the order that they are filled.

NOTE
The information in the table below also serves as a guide for preparing appropriate premix gases.

Type	Gas mixture (wavelength)	Partial pressure [mbar]	Gas	Pressure [%]	Gas connection	Total pressure [mbar]
COMPex*Pro* 102 **COMPex*Pro* 110**	ArF (193 nm)	100 160 2340 400	F_2/He Ar Ne He	0.17/3.16 5.33 78.00 13.33	Halogen Rare Buffer Inert	3000
	KrF (248 nm)	80 100 3120	F_2/He Kr Ne	0.12/2.30 3.03 94.55	Halogen Rare Buffer	3300
	XeCl (308 nm)	80 60 3060	HCl/H_2/He Xe Ne	0.13/0.02/2.35 1.87 95.63	Halogen Rare Buffer	3200
	XeF (351 nm)	120 15 3165	F_2/He Xe Ne	0.18/3.46 0.45 95.91	Halogen Rare Buffer	3300
COMPex*Pro* 201 **COMPex*Pro* 205**	ArF (193 nm)	100 200 2900	F_2/He Ar Ne	0.16/2.96 6.25 90.63	Halogen Rare Buffer	3200
	KrF (248 nm)	60 130 3210	F_2/He Kr Ne	0.09/1.68 3.82 94.41	Halogen Rare Buffer	3400
	XeCl (308 nm)	60 100 3440	HCl/H_2/He Xe Ne	0.08/0.02/1.57 2.78 95.55	Halogen Rare Buffer	3600
	XeF (351 nm)	130 15 2855 300	F_2/He Xe Ne He	0.20/3.74 0.45 86.52 9.09	Halogen Rare Buffer Inert	3300
COMPex*Pro* F_2	F_2 (157 nm)	60 2940	F_2/He He	0.1/1.9 98	Halogen Inert	3000

A0510COMPPRO

4.2.3 Power Supply

CAUTION
Risk of damaging laser device!
Improper installation can cause serious mains supply line damage.
The mains supply line must be installed with strain-relief in a cable channel.

The laser device requires a permanently connected mains supply. The specifications of the electrical connection are listed below.

NOTE
Each COMPex*Pro* laser device is factory set at either 230 V or 120 V. All rated voltages can vary by ±12 %.

Type	Frequency	Phases	Wires	Apparent load	Current
230 V Version					
COMPex*Pro* 102	50 / 60 Hz	1	3	1.5 kVA	6 A
COMPex*Pro* 110	50 / 60 Hz	1	3	3.0 kVA	13 A
COMPex*Pro* F_2	50 / 60 Hz	1	3	3.0 kVA	13 A
COMPex*Pro* 201	50 / 60 Hz	1	3	1.5 kVA	6 A
COMPex*Pro* 205	50 / 60 Hz	1	3	3.0 kVA	13 A
120 V Version					
COMPex*Pro* 102	50 / 60 Hz	1	3	1.5 kVA	12 A
COMPex*Pro* 110	50 / 60 Hz	1	3	3.0 kVA	25 A
COMPex*Pro* F_2	50 / 60 Hz	1	3	3.0 kVA	25 A
COMPex*Pro* 201	50 / 60 Hz	1	3	1.5 kVA	12 A
COMPex*Pro* 205	50 / 60 Hz	1	3	3.0 kVA	25 A

NOTE
The electrical connection is described in Section 4.3.5 on page 92.

A0510COMPPRO

4.2.4 Cooling Water

The COMPex*Pro* 102 and COMPex*Pro* 201 are fully aircooled.

Installation of the water cooling is only required for COMPex*Pro* 110, COMPex*Pro* F_2 and COMPex*Pro* 205. The lasers are optionally equipped with built-in temperature stabilization to optimize the gas temperature of the laser tube by regulation of the water flow.

CAUTION
Risk of corrosion of the laser heat exchange!
Do not use deionized or distilled water.

NOTE
A) Suspended particles in the cooling water can cause sedimentation in or even clog the cooling circuit. We, therefore, strongly recommend the installation of a particle filter in the external water supply line.
B) At high duty cycle, more than 1000 liters of cooling water are needed a day. For cost as well as environmental reasons, we recommend the use of a closed circuit cooling water system with a water chiller.

Temperature Range (at water inlet))	5 to 20 °C for 100 % duty cycle
Flow rate:	1 to 5 l/min (depending on water temperature)
pH-value	6 to 9
Pressure	less than 4 bar (abs.)
Heat transfer to water	less than 1.5 kW
Connectors	10 mm SERTO

NOTE
The water connections are described in Section 4.3.6 on page 93.

A0510COMPPRO

4.2.5 Air Intake / Exhaust

The COMPex*Pro* is cooled by the ambient air. Consequently, it is important to ensure compliance with the specified environmental conditions (see Section 4.2.1 on page 75).

Under normal operating conditions, the exhaust air does not contain any toxic gases or by-products. Nevertheless, certain failure scenarios may cause the exhaust air to contain a small concentration of halogen gas or ozone and should, therefore, be treated accordingly.

Effective protection is only guaranteed if the exhaust hose is guided to an appropriate industrial ventilation system.

WARNING
Toxic gas hazard!
Lead the exhaust of the laser and vacuum pump into an appropriate industrial ventilation system.
Make sure that the exhaust of the laser and vacuum pump is not connected to the ducting of systems used for the processing of breathing air (e.g. air conditioning or ventilating systems).

Flow rate (approx.)	200 m³/h
Heat transfer to exhaust	less than 1.0 kW
Exhaust hose diameter	150 mm
Exhaust hose length	3 m

NOTE
The location of the air intake and exhaust is indicated in Section 4.3.7 on page 94.

A0510COMPPRO

4.3 Connections and Space Requirements

This section specifies the connections and space that is required for the installation of the COMPex*Pro* laser device.

4.3.1 Dimensions and Weight

COMPex*Pro* 100

Dimensions (L × H × B)	≈ 1300 mm (51.2 in) × 795 mm (31.3 in) × 385 mm (15.2 in)
Weight	250 kg (551.2 lb)

COMPex*Pro* F_2

Dimensions (L × H × B)	≈ 1300 mm (51.2 in) × 795 mm (31.3 in) × 385 mm (15.2 in)
Weight	270 kg (594.7 lb)

COMPex*Pro* 200

Dimensions (L × H × B)	≈ 1700 mm (66.9 in) × 795 mm (31.3 in) × 385 mm (15.2 in)
Weight	325 kg (716.5 lb)

Vacuum Pump

Dimensions (L x H x B)	
- without halogen filter	≈ 230 mm (9.1 in) × 450 mm (17.7 in) × 240 mm (9.4 in)
- with halogen filter	≈ 230 mm (9.1 in) × 530 mm (20.9 in) × 240 mm (9.4 in)
Weight	23 kg (50.7 lb)

The physical dimensions are shown in Figures 32 and 33.

A0510COMPPRO

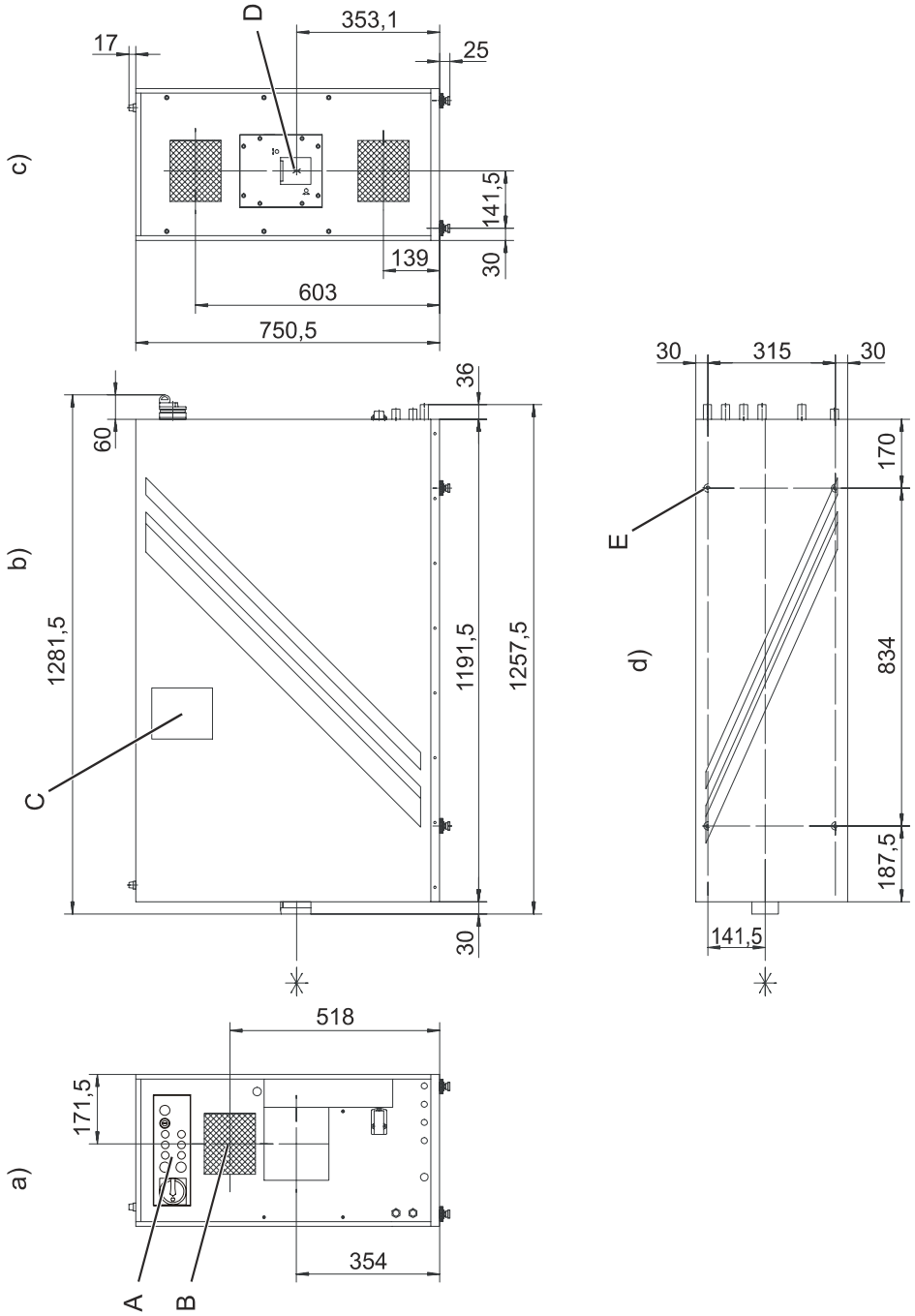


Figure 32: *Dimensions COMPex*$\mathcal{Pro}$ *100 Series and COMPex*$\mathcal{Pro}$ *F_2 Series*

Key to Figure 32:

a) Connection side	A Operating panel with fuses
b) Service side	B Air outlet
c) Beam exit side	C Thyratron adjustment panel cover
d) Top	D Beam exit
	E Foot

A0510COMPPRO

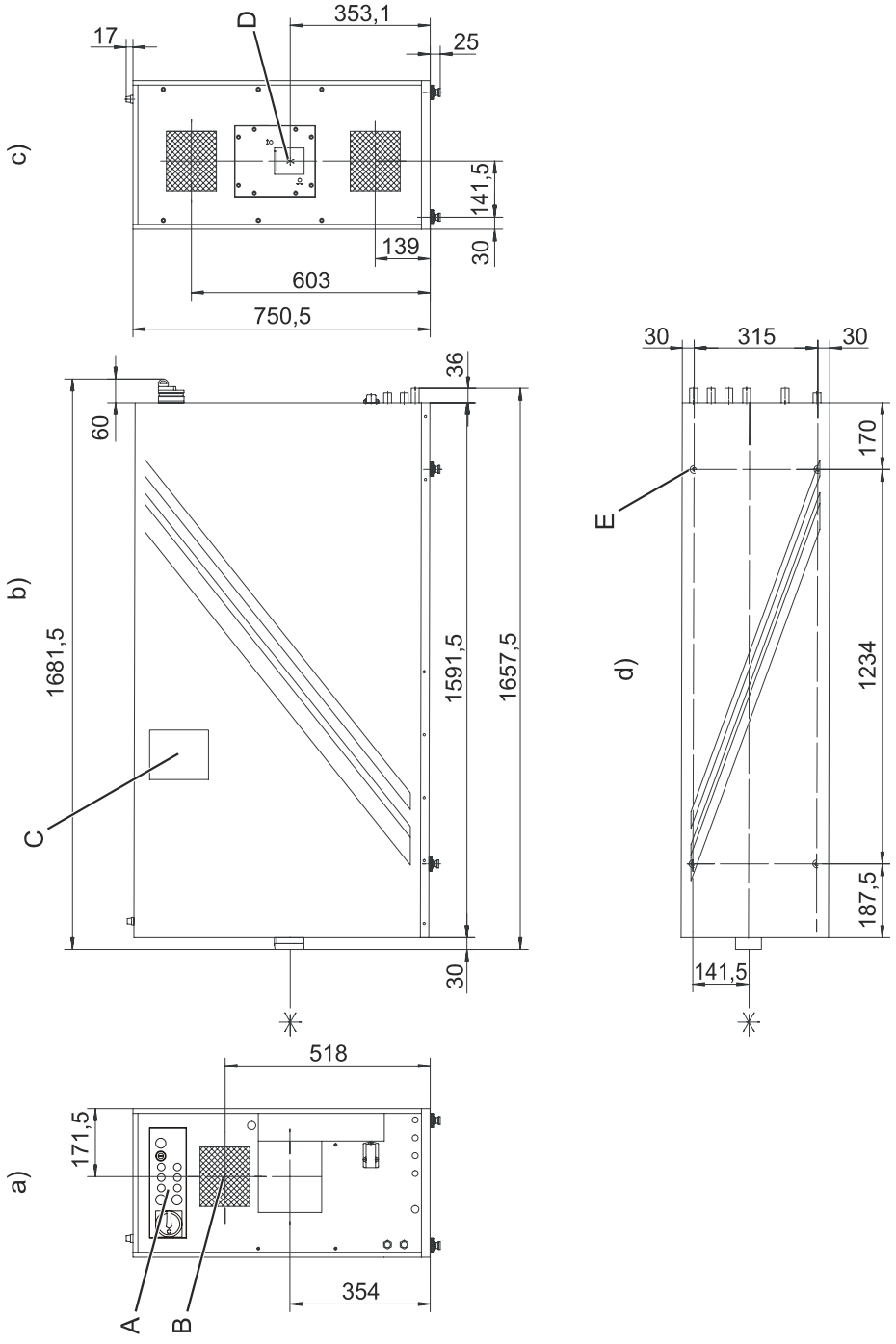


Figure 33: *Dimensions COMPex*$\mathcal{Pro}$ *200 Series*

Key to Figure 33:

a) Connection side
b) Service side
c) Beam exit side
d) Top

A Operating panel with fuses
B Air outlet
C Thyratron adjustment panel cover
D Beam exit
E Foot

A0510COMPPRO

4.3.2 Beam Exit Position

The COMPex*Pro* is equipped with height-adjustable feet. These enable the beam exit position to be vertically adjusted between 378 mm and 418 mm.

The position of the beam exit aperture is shown in Figure 34 (A). The beam exit is 141.5 mm away from the rear foot.

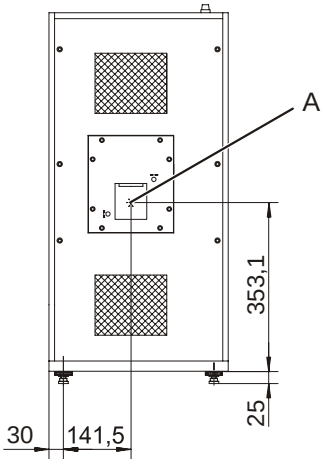


Figure 34: *Beam exit position*

A0510COMPPRO

4.3.3 Foot Configuration

The laser device is equipped with four feet. To compensate for permissible variations in the flatness of the floor, the four feet are height-adjustable. The adjustment range of each foot is indicated in Figure 35.

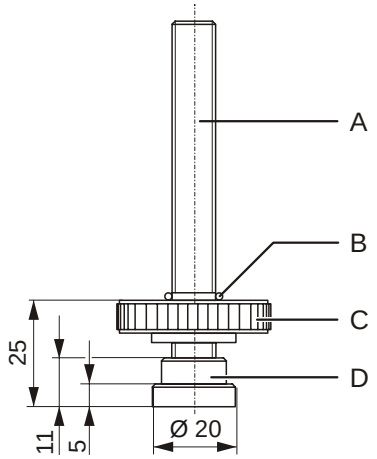


Figure 35: *Foot configuration*

Key to Figure 35:

A	Threaded rod	C	Knurled nut
B	Viton ring Ø10x2	D	Foot

Each foot has a diameter of 20 mm. The shank of the foot has a size M10 thread. The adjustment range of the foot is 40 mm.

The positions of the feet on the laser device are shown in Figure 32 (d) and Figure 33 (d).

A0510COMPPRO

4.3.4 Gas Connections

The positions of the individual gas connections on the laser device are shown in Figure 36.

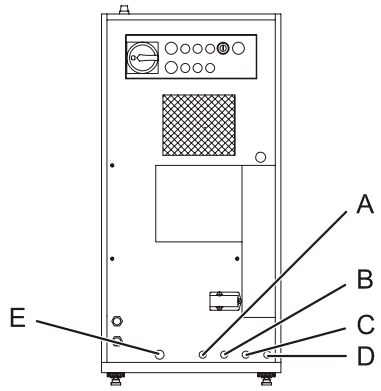


Figure 36: *Gas connections*

Key to Figure 36:

A	Inert gas connection	D	Buffer gas connection
B	Halogen gas connection	E	Vacuum pump connection
C	Rare gas connection		

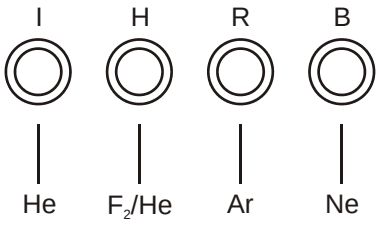
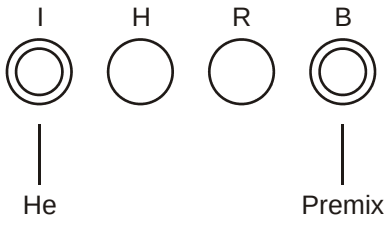
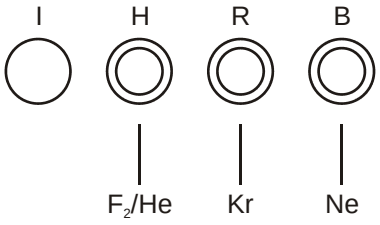
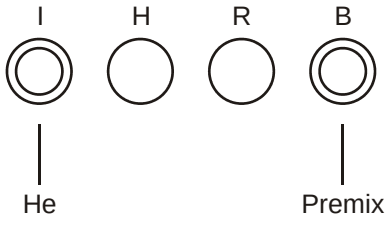
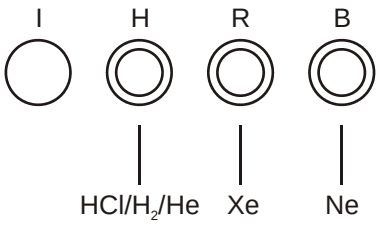
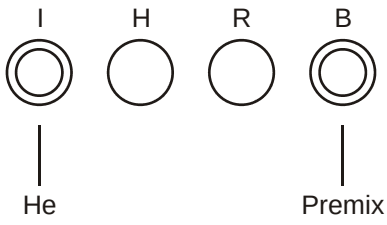
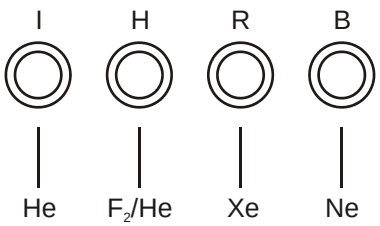
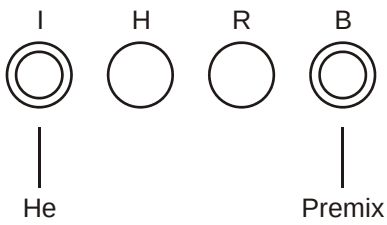
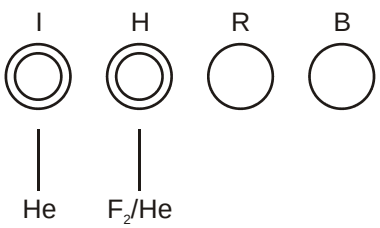
Specifications:

Gas connections	6 mm Gyrolok
Gas lines	316 L stainless steel, electropolished inside, 6 mm outer diameter, degreased
Vacuum pump connection	Material will be supplied with the vacuum pump

NOTE
A) For safety reasons, the halogen supply line from an external gas cylinder should have a double wall tubing.
B) Unless otherwise agreed with COHERENT LAMBDA PHYSIK, a premix cylinder has to be connected to the BUFFER gas connection and a helium cylinder to the INERT gas connection.
C) Gas connections that are not used have to be blanked off with the stainless steel caps that are supplied with the laser device.

A0510COMPPRO

The table below indicates which gases - single or premix - are to be connected for a given laser gas.

Laser Gas	Single Gas Connection	Premix Gas Connection
ArF[a]		
KrF		
XeCl		
XeF[b]		
F_2		

a. Inert gas (Helium) only for COMPex*Pro* models 102 and 110
b. Inert gas (Helium) only for COMPex*Pro* models 201 and 205

A0510COMPPRO

4.3.4.1 Pressure Regulators

CAUTION
Risk of damaging the gas system!
Halogen gases corrode most metals. In addition, the use of unsuitable pressure regulators can contiminate the gas mixture .
Only use pressure regulators made of stainless steel that are suitable for halogen gases. Contact the supplier to ensure that the pressure regulator is suitable for the intended use.

Pressure regulators are supplied by gas manufacturers. Lambda Physik recommends pressure regulators which are designed to operate within the pressure range of the respective gas (see Section 4.2.2 on page 76). Stainless steel regulators are required for halogen gases.

4.3.4.2 Gas Cabinets

WARNING
Toxic gas hazard!
Halogens are extremely reactive and resistant oxidants.
Avoid inhalation and skin contact with halogens.

Gas cylinders, especially those containing fluorine and hydrogen chloride gas mixtures pose a safety hazard because of the risk of leakage. In order to diminish this risk, safety gas cabinets are available. Please contact your gas supplier for further information.

4.3.5 Electrical Connection

The COMPex*Pro* is connected to the mains power supply socket through a 3 m long mains cable that is hard wired to the laser device (see Figure 37, A). A wall socket configured according to the specifications indicated in Section 4.2.3 has to be located in the immediate vicinity of the laser device.

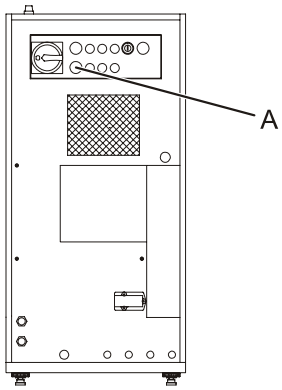


Figure 37: *Position of the mains connection*

Specifications:

Type of mains plugs	IEC Standard

A0510COMPPRO

4.3.6 Cooling Water Connections

The location of the cooling water connections on the laser device are indicated in Figure 36.

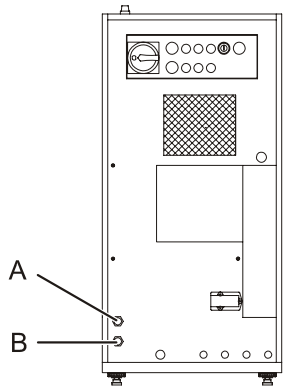


Figure 38: *Cooling water connections*

Key to Figure 38:

A	Cooling water inlet	B	Cooling water outlet

Specifications:

Connections	10 mm SERTO
Piping	½ inch, length: 3 m

A0510COMPPRO

4.3.7 Air Intake and Exhaust Connections

The laser device has two air intakes on the beam exit side (see Figure 39, A) and a central exhaust outlet on the connection side (B). The exhaust is to be connected to an appropriate industrial ventilation system (see Section 4.2.5 on page 83).

NOTE
To ensure an adequate supply of cooling air, the laser device has to be situated in the specified maintenance area (see Section 4.3.9 on page 98).

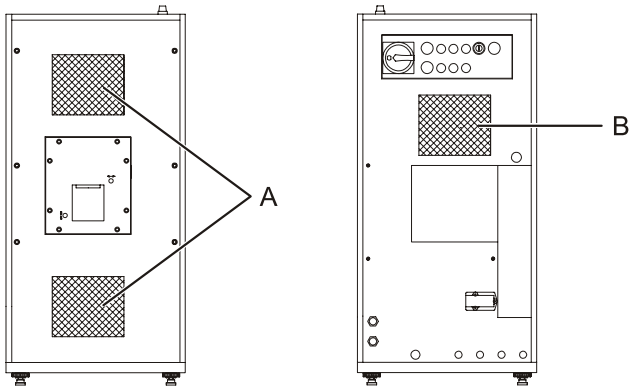


Figure 39: *Location of air intake and exhaust*

Key to Figure 39:

A	Air intake	B	Exhaust

Specifications:

Diameter	150 mm
Hose length(max.)	3 m If the total length of the exhaust line exceeds 5 m, an additional blower is required

A0510COMPPRO

4.3.8 Control Lines

This section describes the COMPex*Pro* interfaces.

4.3.8.1 Serial Interface

The laser can be controlled by an external PC system using the interface specified in this section.

The connector is a 25 pole Sub D-type male connector.

PIN	Signal	Specification	Description
2	TXD	O, RS232	Transmit Data
3	RXD	I, RS232	Receive Data
7	GND		Signal Ground

Data format:

Data bits	8
Parity	none
Stop bit	1
Baud rate	9600 bps

4.3.8.2 Remote Socket

The remote socket allows the laser device to be connected to external safety circuits. To enable laser operation, pins 2 and 3 have to be bridged, otherwise the interlock message ”REMOTE“ will occur.

NOTE
The Remote Interlock contact only switches off the high voltage and not the complete system. After closing the contact, the laser can be restarted. To prevent this, the contact has to be integrated in an external EMERGENCY OFF circuit.

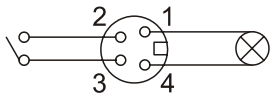


Figure 40: *Remote socket*

Specifications:

Pin 2 to 3:	24 V AC
Pin 1 to 4:	24 V AC / 100 mA

A0510COMPPRO

4.3.8.3 Trigger Signal Ports

The COMPex*Pro* laser device has two BNC trigger signal ports:

– External Trigger in (Ext. Trig.)

– Sync. Out

External Trigger In

This part allows external triggering of the laser.

Specifications:

Connection	BNC Galvanic isolation through optocoupler
Voltage	+3.3 V to +5 V
Impedance	≥ 5 kΩ
Signal length	≥ 15 µs the laser pulse occurs on the positive flank of the trigger signal

Delay

The delay between the external trigger signal and laser pulse is approximately 1 µs. This delay varies by ±10 ns depending on the laser mode (warm-up or laser on, repetition rate and pulse energy).

The COHERENT LAMBDA PHYSIK Excimer Laser Synchronisation Unit (synchronisation unit) can be used for applications that require a constant delay:

Adjustable delay	1 µs to 3.5 µs
Step width	10 ns
Precision	±1 ns
Transient	15 pulses from laser start

A0510COMPPRO

4.3.8.4 Sync. Out Signal

The Sync. Out Signal is sent by the Communications Interface (CI). It informs external devices that a trigger signal (either internal or external) has just been given.

NOTE
If COD (Charge On Demand) is active, there is a time delay between the Sync. Out Signal and firing of the laser. For more information about this delay, see Section 6.4.1 on page 165.

Specifications:

Connection	BNC Galvanic isolation through optocoupler
Voltage	+3.3 V to +5 V
Impedance	≥ 1 kΩ
Signal length	≥ 15 µs the signal occurs on the positive flank of the trigger signal

A0510COMPPRO

4.3.9 Maintenance Area

The laser device has to be installed in area which allows the maintenance covers to be removed and installation and maintenance work to be performed. The necessary maintenance area is indicated in Figures 41 and 42.

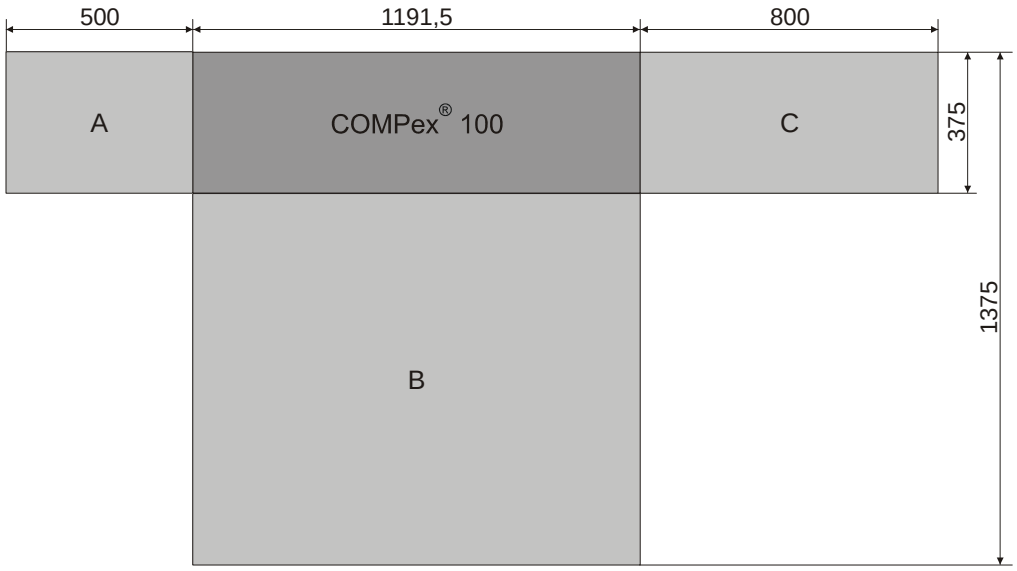


Figure 41: *Maintenance area of COMPex*$\mathcal{Pro}$ *100 series and COMPex*$\mathcal{Pro}$ F_2

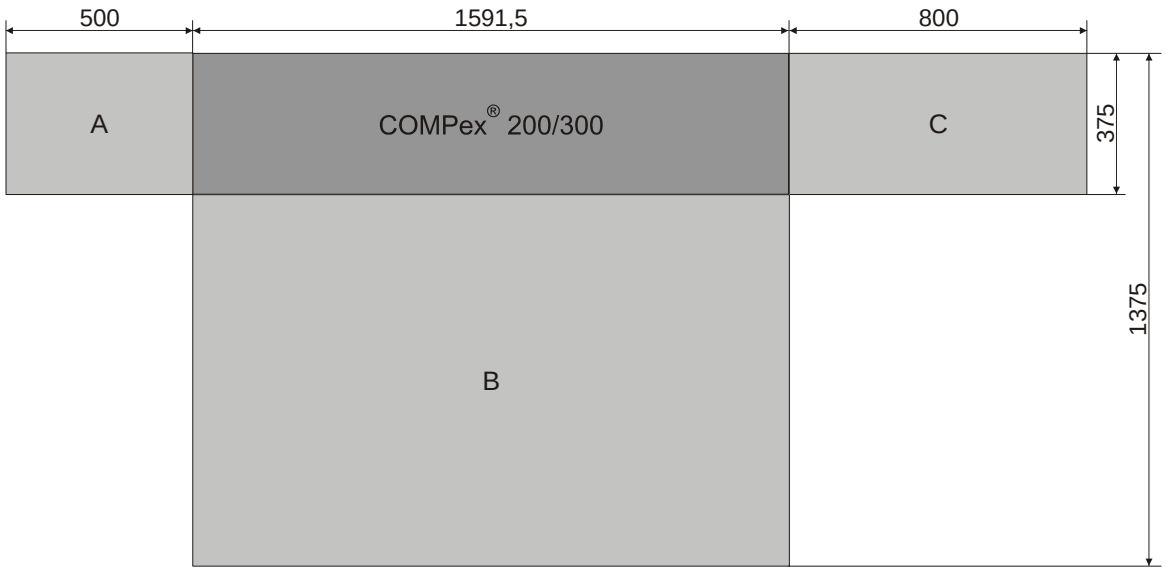


Figure 42: *Maintenance area of COMPex*$\mathcal{Pro}$ *200 series*

A0510COMPPRO

Maintenance areas:

Position in Fig. 41 and 42	Maintenance area	Dimensions B x T [mm]	Area [m^2]
COMPex*Pro* 100 and COMPex*Pro* F_2			
	Footprint	1191.5 x 375	0,45
A	Beam exit side	500 x 375	0,19
B	Service area	1191.5 x 1000	1,19
C	Connection side	800 x 375	0,30
COMPex*Pro* 200			
	Footprint	1591.5 x 375	0,60
A	Beam exit side	500 x 375	0,19
B	Service area	1591.5 x 1000	1,59
C	Connection side	800 x 375	0,30

4.4 Accessories

4.4.1 Vacuum Pump

Type: Becker VTC 6/2

The vacuum pump is connected to the laser device with a 3 m supply cable and does not require an additional power supply.

For more information, see the attached vacuum pump manual.

4.4.2 Halogen Filter

Type: Standard
Supplier: COHERENT LAMBDA PHYSIK (order number: 261 068)

The halogen filter is fitted to the vacuum pump and requires no further connections.

A0510COMPPRO

A0510COMPPRO

5 INSTALLATION

This chapter describes the installation of the laser device.

It must be read:

– prior to initial installation,

– after transportation,

– prior to re-installation after storing the laser device.

5.1 Transport and Unpacking

This section describes the internal transport and unpacking of the laser device. After following all procedures detailed in this chapter, the laser device is ready for installation. To ensure that the laser device is moved and unpacked safely and that no damage occurs, strictly adhere to the instructions in this chapter.

In addition, ensure that the requirements for transport and storage are complied with (see Section 4.2.1.1 on page 75). Check that all transport routes, corridors and all exits and entrance ways provide suffienct space for the safe movement of the laser device in its respective packing stage.

WARNING
Risk of injury or damage!
Failure to observe the transportation requirements and restrictions in this section may result in injury to persons or damage to equipment. Persons responsible for transporting the system must ensure that all transport requirements are complied with.

5.1.1 Safety

When moving the laser device and its components, always follow the standard safety precautions and practices for the transportation and handling of the heavy equipment.

WARNING
Risk of crushing!
The laser device together with its components, accessories and packaging weighs, depending on version, up to 395 kg (870.8 lb). Always use suitable transport equipment to lift and transport the laser device.

A0510COMPPRO

CAUTION
Risk of damaging the laser device!
During transportation and installation, keep the laser device as horizontal as possible. The laser device can be tilted max. 5° around the beam axis and 20° longitudinally for a short period (see Figure 43).

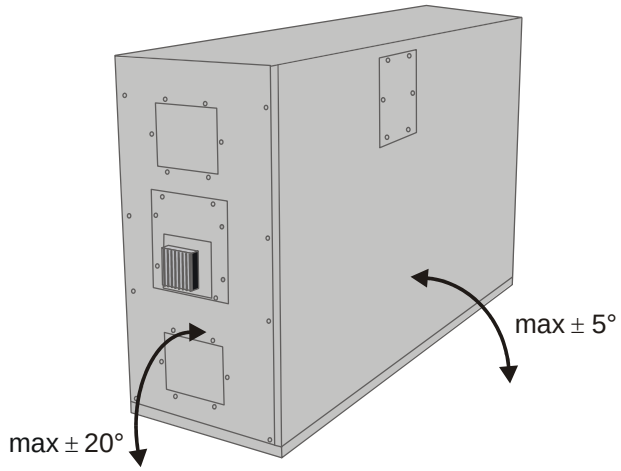


Figure 43: *Permitted tilting gradients*

CAUTION
Risk of damaging laser device feet!
The COMPex*Pro* laser device is to be transported carefully.
Especially if attached to the base plate of the rigid transport packaging avoid sudden shocks and, if tilted, avoid vibrations.

5.1.2 Transport and Storage Conditions

Ensure that the conditions described in Section 4.2.1.1 on page 75 are maintained while transporting and storing the laser device .

A0510COMPPRO

5.1.3 Floor Loads

CAUTION
Risk of structural damage!
All floors an the proposed transport route or at the proposed storage/ installation location must be checked to ensure that they can withstand the weight of the laser device and fork lift truck or similar device (whatever used).

It is the responsibility of the customer to provide Lambda Physik and/or the system manufacturer with:

– Accurate information regarding floor loading capabilities.
This information is necessary to determine the type of transportation to be used.

– Elevator loading capacities
When elevator transport is intended, the loading capability of the elevator must be verified.

5.1.3.1 Packaging Dimensions and Weight

Laser Device with Rigid Transport Packaging

Dimensions (L x H x B)	1820 mm x 1030 mm x 540 mm
Weight	
- COMPex*Pro* 100 series	345 kg
- COMPex*Pro* F_2 series	365 kg
- COMPex*Pro* 200 series	395 kg

Accessories (separately packed for COMPex*Pro* 200 series)

Dimensions	660 mm × 520 mm × 430 mm or 520 mm × 520 mm × 470 mm
Weight	depending on configuration

Laser Device without Rigid Transport Packaging

The weight and dimensions of COMPex*Pro* laser devices and accessories without transport packaging are indicated in Section 4.3.1 on page 84.

A0510COMPPRO

5.1.4 Transport Packaging

This section describes the means of packaging the COMPex*Pro* to ensure safe shipment and delivery in the required condition.

NOTE
Always retain the transport packaging to ensure optimum protection of the laser device during sub sequent shipment.

The transport packaging of the COMPex*Pro* 100 series consists of a single transport container. This contains the laser device together with all accessories and components removed from the laser device for transport.

The accessories and components of the COMPex*Pro* 200 series laser devices are packed in a seperate box.

The transport packaging of the laser device is in two-stages:

– the rigid transport packaging

– the anti-static (polyethylene) inner cover.

The rigid transport packaging (see Figure 44) fully encapsulates the laser devices and inner cover. It consists of a plywood base pallet (B) and plywood upper panels (A) at the sides, front rear and top.

Figure 44: *Rigid transport packaging*

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Placed on the base pallet are two shock absorbing buffers (see Figure 45). When the laser device feet are placed in the locating holes of the buffers (A), the laser device is secured in position when the rigid transport packaging is closed.

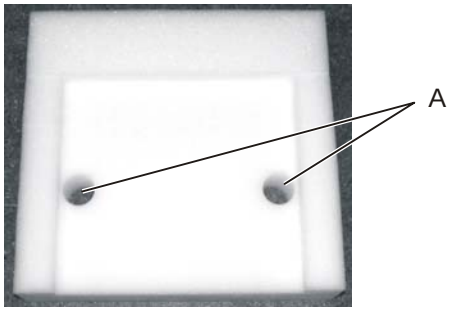

Figure 45: *Shock absorbing buffers*

The laser device is to be stored in the rigid transport packaging.

5.1.5 Transport and Unpacking Procedure

This section provides an overview of the unpacking and internal transport of the laser device. Further information is provided in the indicated sections of this chapter.

Step	Action	Further information:
1	Unload transport container from truck and set down in goods-in area	Section 5.1.6, page 106
2	Perform incoming goods inspection	Section 5.1.7, page 106
3	Move container to storage / unpacking area	Section 5.1.6, page 106
4	Remove rigid transport packaging	Section 5.1.8, page 107
5	Transport laser device to unpacking or installation area	Section 5.1.9, page 109
6	Remove anti-static inner covers	Section 5.1.10, page 110
7	Where necessary, transport laser device to installation area	Section 5.1.9, page 109

A0510COMPPRO

5.1.6 Transport / Lifting with Rigid Packaging

WARNING
Risk of crushing!
The laser device together with its accessories and packaging, depending on version, weighs up to 395 kg (870.8 lb).
Prevent tipping or dropping during lifting and transportation.

A suitable for lift truck or similar device is required to lift the laser device. Ensure that the fork length and loading capacity is sufficient to safely lift the laser device in its packaging.

NOTE
For information regarding the size and weigth of the laser device in its packaging see Section 5.1.3.1 on page 103.

The laser device can be lifted longitudinally or from the side. Set the forks as far apart as possible to safely lift the laser device.

5.1.7 Incoming Goods Inspection

Purpose

Check the laser device for possible transport damage.

NOTE
A) To monitor the handling of the laser device during transportation, SHOCKWATCH® indicators are fixed to the rigid transport packaging as well as inside the laser device. These turn from white to red when subject to excess shocks.
B) After ensuring that the laser device is not damaged, check the contents of the shipment against the packing list provided and sign the delivery note. If any parts are missing, immediately contact Lambda Physik. The contact address is indicated on the reverse side of the cover sheet of this manual.

Tools and Materials

- None

Performing Incoming Goods Inspection

1. Ensure that no SHOCKWATCH® indicators on the rigid transport packaging have turned to red.
2. If one or more SHOCKWATCH® indicators is red, refer to the next section.

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Damaged Deliveries

3. Do not refuse the shipment.
4. Make a corresponding notation on the delivery receipt document and inspect for visible signs of damage to the rigid transport packaging.
5. If there are no visible signs of damage to the packaging, remove the individual packaging stages and check for visible signs of damage to the laser device.
6. If there is no sign of visible damage to the laser device, install the laser device. If the laser device is defective, immediately contact Lambda Physik for further inspection and rectification.

5.1.8 Remove Rigid Packaging

Purpose

Remove the top and side panels from the rigid transport packaging. At the end of this procedure the laser device remains attached to the base pallet and is protected by the inner cover.

Tools and Materials

- suitable lifting truck (fork-lift truck)
- clip removal tool (provided)
- screwdriver for removal of clip removal tool

Preparation

1. Using the fork lift truck or appropriate device, move the laser device to the location whereit is to be unpacked.
2. Set down the laser device in the unpacking location.

NOTE
The original packaging is needed to re-ship the laser device. Store the removed packaging in such a way that no parts are lost or damaged.

A0510COMPPRO

3. Unscrew and remove the clip removal tool (see Figure 46, A) from the rigid transport packaging.

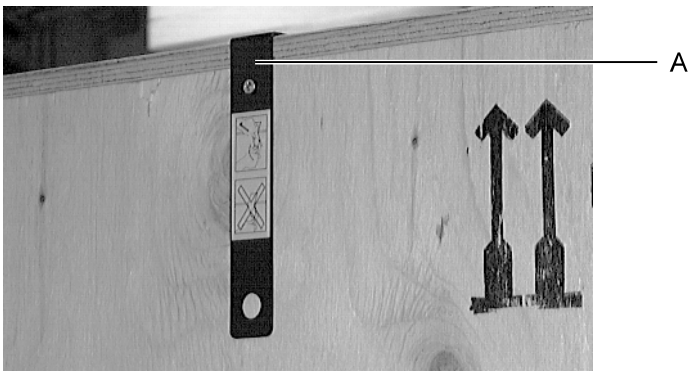

Figure 46: *Location of clip removal tool*

CAUTION
Risk on injury caused by incorrect use of the clip removal tool!
The transport packaging clips are under tension. Do not use excess force to remove. While levering off, use the other hand to restrain movement.

4. Working from the top downwards, remove the clips from the rigid transport packaging. Push the clip removal tool into the recess on the clip, press against the clip to control movement and lever off (see Figure 47).

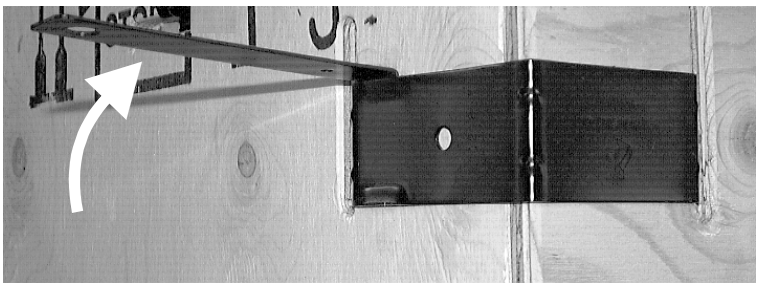

Figure 47: *Removing the clips*

5. When the corresponding clips have been removed, remove the top, front, rear and side panels of the packaging.

Storing the Transport Packaging

6. Stack the disassembled panels of the rigid transport packaging and accessory packaging onto the base pallet.

NOTE
When stacking, ensure that the outer cover does not become contaminated or damaged and that the inside surfaces of the panels cannot become contaminated.

A0510COMPPRO

5.1.9 Transport / Lifting without Rigid Packaging

NOTE
For information regarding the size of the laser device, see Section 5.1.3.1 on page 103.

WARNING
Risk of crushing!
The COMPex*Pro* laser device together with its accessories and packaging weighs, depending on version, up to 395 kg (870.8 lb). Prevent tipping or dropping during lifting and transportation.

CAUTION
Risk of soiling or damaging the laser optics!
To avoid the formation of condensed water, ensure that the max. permissible temperature gradient (5 °C/h) is maintained while moving the laser device from the storage area.

Ensure that all passageways, corridors and access points have sufficient clearances. Pay particular attention to the clearences required to turn the laser device.

A suitable fork lift truck or similar device is required to lift the laser device. Ensure that the fork length and/or the loading capacity are sufficient to safely lift the laser device.

When using a fork lift truck, always transport or lift the laser device together with the base pallet.

When using a crane, position the lifting harness or belt as near to the laser device's feet as possible.

CAUTION
Risk of damaging the laser device!
incorrect lifting can cause serious damage. Use lifting points as far apart as possible to safely lift the laser device.

A0510COMPPRO

5.1.10 Remove Anti-Static Inner Cover

Purpose

Remove the anti-static inner cover from the laser device and unpack the accessories.

Tools and Materials

- knife for cutting sealing tape

Preparation

1. Move the laser device and accessories to the installation area.

Removing the Inner Covers

NOTE
The original packaging is needed to re-ship the laser device. Store the removed packaging in such a way that no parts are lost or damaged.

2. Remove the tape that seals the anti-static inner cover onto the laser device.
3. Lift the anti-static inner cover off the laser device.
4. Take the accessories out of the packaging and clean the accessories if required.

A0510COMPPRO

5.2 Installation

This sec tion describes the installation of the laser device. When all procedures in this section have been completed, the laser device can be commissioned.

5.2.1 Installation Procedure

This section provides an overview of the procedure to install the laser device. Further information is provided in the indicated sections of this chapter.

Step	Action	Further information:
1	Set down laser device at the final installation location	Section 5.2.2, page 112
2	Visually check for damage	Section 5.2.3, page 113
3	Connect remote interlock circuit	Section 5.2.5, page 114
4	Connect mains power supply	Section 5.2.6, page 115
5	Connect exhaust	Section 5.2.7, page 117
6	Connect gas lines	Section 5.2.8, page 122
7	Connect water lines	Section 5.2.9, page 122
8	Connect signal lines	Section 5.2.10, page 128
9	Check gas lines for leaks and passivate the lines	Section 5.2.11, page 130
10	Check laser tube for leaks	Section 5.2.12, page 134
11	Fill laser tube with laser gas (perform “New Fill“)	Section 5.2.13, page 135

A0510COMPPRO

5.2.2 Position Laser Device

Purpose

Set down the laser device at the final installation location and adjust the feet to the required height.

Tools and Materials

- Spirit level
- Multigrip pliers or gaspipe pliers

Preconditions

- Laser device situated at the final installation location

Preparation

1. Lay the spirit level on to the laser device housing.

Adjusting the Height of the Feet

CAUTION
Risk of damaging the laser device!
The feet can drop out of the laser device if over-loosened. Never exceed the maximum adjustment height of 65 mm between the base plate of the laser device and the installation surface.

2. Use the pliers to turn the knurled nut (see Figure 48, A) on one of the feet on the beam exit side to the right until it protrudes by approx. 5 mm.

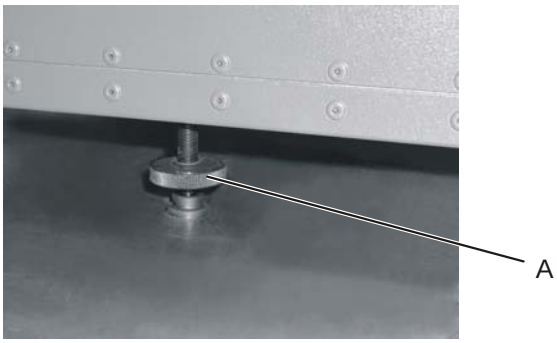

Figure 48: *Laser device foot*

3. Repeat step 2 for the other feet.

NOTE
Adjust the feet crosswise in small steps so that the weight of the laser device is always evenly support.

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4. Repeat steps 2 and 3 until all feet are at the correct height for the desired beam height and the laser device is level.

5.2.3 Visual Check

Purpose

Ensure that the laser device has reached the installation location without being damaged, in a safe and clean condition and that all safety lables are complete and legible.

Tools and Materials

- None

Check Laser Device

1. Check the laser device housing for visible signs of damage, impurities and contamination.

WARNING
Risk of injury!
Misuse or improper handling of the laser device can cause serious or, in certain situations, even lethal injuries.
Never put the laser device into operation if safety labeling is incomplete. Immediately replace damage or missing safety lables.

2. Check that all safety labels are attached as indicated in Section 3.3 on page 61 and that no safety labels are damaged.

5.2.4 Transport Locks

The COMPex*Pro* is delivered without any transport locks.

A0510COMPPRO

5.2.5 Connect Remote Socket

Purpose

Connect, according to the international standard IEC 825, remote interlock switches and an external laser radiation warning lamp (supplied by the customer) to the Remote socket on the laser device (see also Section 2.5.4 on page 30 and Section 4.3.8.2 on page 95).

Connecting the Door Interlock Switch

1. Connect pins 2 and 3 (e.g. via a switch that opens when a door is opened, thus shutting down the laser and preventing accidental beam contact).

NOTE
The laser can only operate when pins 2 and 3 are connected (with a closed switch, a short-circuit plug, etc.).

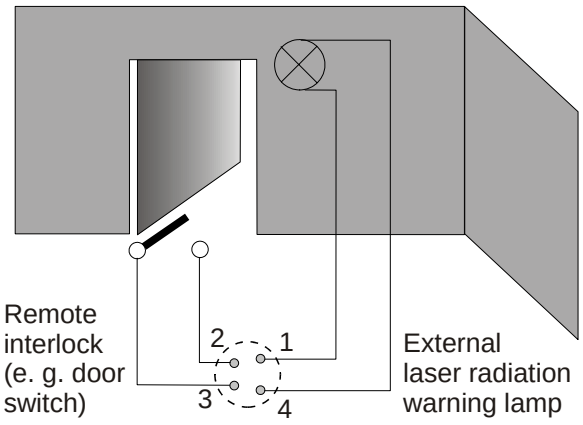

Figure 49: *Remote socket connections*

Connecting the Laser Warning Lamp

2. Connect pins 1 and 4 (e.g. with a laser radiation lamp that warns upon entering a room that the laser in on).

Installation may vary due to local requirements.

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5.2.6 Connect Mains Power Supply Lines

Purpose

Connect the laser device and vacuum pump to the mains power supply at the installation location.

WARNING
Risk of electrocution!
Work on the electrical system and equipment of the laser device shall only be carried out only by skilled electricians or by instructed persons under the supervision and guidance of a skilled electrician and in accordance with electrical engineering rules and regulations.

A mains power supply outlet is required for the laser device. Note the power consumption of these devices:

– COMPex*Pro* 102, 201: 1.5 kVA (max.)

– COMPex*Pro* 110, 120, 205, F_2: 3.0 kVA max.

NOTE
The power supply line of the laser device is to be protected through an approved and correctly rated circuit interruption device, in accordance with valid national and local electrical standards.

Tools and Materials

- Wire cutter and stripper
- If used, plug for your local mains wall socket
  (The mains plug (30 A) is to be approved in accordance with valid national and local electrical standards!
- Appropriate screwdrivers for the plugs used

Preconditions

- Laser device positioned at the final installation location

A0510COMPPRO

Preparation

1. Locate the vacuum pump in a safe position near to the laser device.

CAUTION
Risk of damaging the laser device!
The laser device is available with a number of mains voltage and frequency configurations. Ensure that the laser device is configured for your local voltage and frequency. .

2. Compare the settings indicated on the type plate with the mains voltage and frequency specifications at the installation location. The type plate is situated on the connection side of the laser device (bottom left corner).

Connecting the Laser Device to the Mains Power Supply

1. Ensure that the key switch and main switch are both set to their respective OFF settings.
2. Blank the ends of the mains power supply cable attached to the laser device.
3. Connect the blanked ends to the mains wall plug or wall power outlet. The colors of the cables depend on the power supply version:
   - black or brown: phase
   - white or blue: neutral
   - green or yellow/green: ground
4. When used, insert the prepared laser devices mains power supply plug into the mains socket.

Connecting the Vacuum Pump

Please consult the operating instructions for the vacuum pump attached to this manual. The vacuum pump must be connected to the socket on the rear side of the laser device marked with “POWER VACUUM PUMP”.

5. Connect the vacuum pump’s mains power supply cable to the corresponding connection on the connection side of the laser device.

A0510COMPPRO

5.2.7 Connect Exhaust Lines

The COMPex*Pro* has two exhaust lines:

– the exhaust of the laser device housing,

– the laser tube exhaust line (including the vacuum pump and the halogen filter, which is also described in this chapter).

WARNING
Toxic gas hazard!
Ensure that a halogen sensor and an evacuating system are installed in the area of the vacuum pump to avoid hazardous halogen gas concentrations in case of gas leaks during laser tube evacuation.

5.2.7.1 Connect Laser Device Housing Exhaust Line

Purpose

Connect the exhaust line between the exhaust port on the top of the laser device and the building industrial ventilation system. After connection of the exhaust line, any contamination within the laser device housing will be directed into the industrial ventilation system.

NOTE
Under normal operating conditions, the exhaust air does not contain toxic gases or by-products. With certain failure scenarios, however, the exhaust air may contain small concentrations of halogen gas or ozone and, consequently, shall be treated accordingly.

Tools and Materials

- 4 mm Allen key
- Exhaust line assembly (supplied with the COMPex*Pro*)
- Connections to your own ventilation output (minimum internal diameter 150 mm, min. flow rate 200 m³/h)
- Additional blower (when exhaust is longer than 5 m)
- Additional exhaust line (when exhaust line exceeds 5 m)

Preconditions

- Mains power supply connected

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Installing the Exhaust Line

1. Usee the allen key to remove the two screws at the exhaust fan outlet on the rear side of the laser device (see Figure 50).

Figure 50: *Loosen the exhaust fan outlet*

2. Connect the exhaust pipe to the exhaust fan outlet using the two 4 mm allen screws that have just been removed .

WARNING
Toxic hazard!
Lead laser and vacuum pump exhaust hose to an appropriate ventilation system.
Do not connect the exhaust to breathing air systems (i.e. air conditioning or ventilating systems).

3. Connect the other end to the exhaust tube to a suitable ventilation output.
4. Check that the air input filters on the front of the laser are fitted properly and are not obstructed.

Tests and Adjustments

5. Switch on the laser main switch.
6. Check that the exhaust fan, mounted on the top rear of the laser device, is working and sucking air out of the laser device.
7. Check that there are no leaks around the exhaust pipe clamp. If necessary seal any leaks.
8. Switch off the laser main switch.

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5.2.7.2 Connect Laser Tube Exhaust Line (Including Vacuum Pump)

Purpose

Assemble and connect the vacuum pump and halogen filter to the laser device.

During laser operation, the laser tube has to be evacuated to remove the spent excimer laser gas mixture, This gas mixture contains toxic halogens, which are filtered out of the exhaust gas by a halogen filter.

NOTE
Consult the vacuum pump manual (attached to this manual) for a fundamantal description of the installation of the vacuum pump and basic function tests.

Tools and Materials

- Vacuum pump
- Vacuum hose
- Gas exhaust hose (¾" flexible hose)
- 36 mm wrench
- 19 mm wrench
- 6 mm allen key

Preconditions

- Laser device positioned at the final installation location

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Installing the Laser Tube Exhaust Line

NOTE
While mounting the vacuum pump and halogen filter, five plugs are to be removed. Keep these plugs in the service case for future use.

1. Remove the plug from the vacuum pump (see Figure 51)

Figure 51: *Removing plug from vacuum pump*

2. Remove the plastic plug from the halogen filter.
3. Set two of the halogen filter threaded rods into the anti-torsion fork with the arrow on the filter pointing downwards (see Figure 52).

Figure 52: *Inserting halogen filter*

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4. When the anti-torsion fork is not properly adjusted, use the 6 mm allen key to loosen the anti-torsion fork's adjustment screw (see Figure 53), shift the anti-tosion fork into the required position and retighten the adjustment screw.

Figure 53: *Adjusting the anti-torsion fork*

5. Use the 36 mm wrench to tighten the halogen filter onto the vacuum pump .
6. Remove the center plug from the top of the halogen filter.
7. Use the 19 mm wrench to mount the vacuum hose onto the halogen filter.
8. Remove the plastic plug from the laser device connection marked "VACUUM PUMP".
9. Use the 19 mm wrench to attach the (white) vacuum hose to the laser device connection.
10. Remove the plug from the vacuum pump outlet socket.
11. Mount the ¾" gas exhaust hose to the vacuum pump outlet socket.

WARNING
Risk of toxic hazard!
Lead laser and vacuum pump exhaust hose to an appropriate ventilation system.
Do not connect the exhaust to breathing air systems (i.e. air conditioning or ventilating systems).

12. Connect the gas exhaust hose to a suitable ventilation output.

A0510COMPPRO

5.2.8 Connect Gas Lines

The laser devices' gas management system allows gas supply from seperate gas cylinders. Additionally premix gas cylinders and/or the optional halogen source can be used. Consequently, gas line installation varies:

Configuration	Gas types	Connection
Single gases	Halogen	Halogen
	Helium	Inert
	Neon	Buffer
	as specified	Rare
Premix gas and helium	Premix	Buffer (Standard)
	Helium	Inert
Premix, helium and halogen source	Premix	Buffer
	Halogen source	Halogen
	Helium	Inert

To obtain optimum laser performance, observe the following instructions for the gas line installation:

– Only use gases specified in Section 4.2.2 on page 76.

– Only use materials specified in Section 4.3.4 on page 89. This prevents impurities from entering the gas system.

– Store gas cylinders in a dry cabinet to avoid corrosion through moisture.

– Never expose the halogen line to moisture while it contains halogen or traces of halogen as this will corrode it immediately.

– Avoid long and complicated line routings. This a source of impurities entering the system.

– Only use clean and oil-free leak-proof fittings throughout the gas line. Avoid complicated fittings.

– Carefully check for leaks.

– Never use gas lines that have been used for other gases.

NOTE

A) All unused connections must be blanked off with stainless steel plugs delivered with the laser device.

B) For further information about the gas system, please refer to Section 2.4.7 on page 23.

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Tools and Materials

- Gas supply lines as specified in Section 4.3.4 on page 89
- 9/16” wrench
- 13 mm wrench
- Tools for shaping and cutting stainless steel tubing

CAUTION
Incorrect handling can cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas supply system, pressures below 20 bar (abs.) may be critical.

- Gases as specified in Section 4.2.2 on page 76

Preconditions

- Laser device positioned at the final installation location

Preparation

1. Check that pressure regulators are connected to the gas cylinders.
2. Check that the gas supply lines are laid and connected to the pressure regulators (or a halogen source).

CAUTION
Risk of damaging gas connectors!
Cut stainless steel only with an appropriate tool. Do not use a saw: Do not use lubricants.

3. Fit each line with a 6 mm Gyrolok fitting.
4. Check that all gas supply valves are closed.

Connecting the Gas Lines

5. Use the 9/16” wrench to remove the blanking plug from the appropriate gas connector on the laser device.

NOTE
Keep the blanking plug in the service case for further use.

6. Fit the gas line to the appropriate connector on the laser device and tighten until finger tight.

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7. Use the 9/16” wrench to tighten the Gyrolok fittings.

Figure 54: *Tightening the gas connections*

8. Repeat steps 5 to 7 until all supply lines are connected.

Final Checks

9. Check that all connections are properly matched and sealed tightly.
10. Perform a leak test on all newly fitted lines according to Section 5.2.11 on page 130 of this manual.

A0510COMPPRO

5.2.9 Connect Water Lines (COMPex*Pro* 110, COMPex*Pro* 205, COMPex*Pro* F_2)

Purpose

Connect the cooling water inlet and outlet lines to the laser device. The fittings are contained in the service case.

NOTE
Due to the increased power of the COMPex*Pro* 110 and COMPex*Pro* 205, they cannot be air-cooled only and, therefore, require a water cooling supply, when they are continuously operated at repetition rates higher than 20 Hz. The specifications of the water supply are indicated in Section 4.2.4 on page 82.

There are two fundamental types of water line connections (see Figure 55).

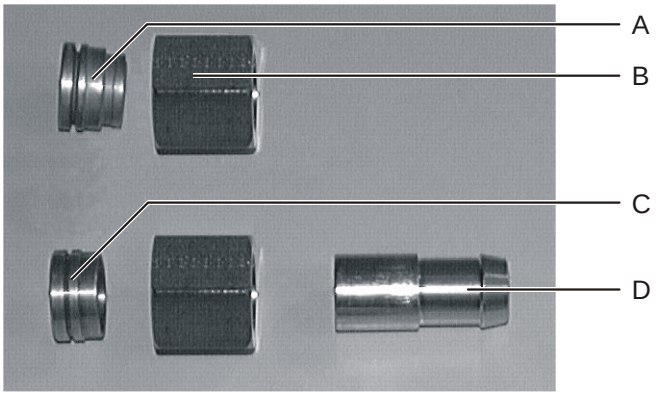

Figure 55: *Water line connections*

Key to Figure 55:

A	Ferrule for ½ inch pipe	C	Ferrule for ½ inch hose
B	Nut (for all connections)	D	Nozzle for ½ inch hose

NOTE
A) This section describes the connection of water hoses to the laser device. Cooling water pipes are to be connected in a similar way using a nut and a ferrule and inserting the pipe instead of the nozzle.
B) The water leakage service kit (part no. 264 089) contains different connectors which shall be sufficient to rectify a water leakage. If necessary, the teflon tape contained may be used to seal threads in the cooling water lines. Never use the teflon tape for the connections at the laser device!

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Tools and Materials

- 2 sets of hose connectors

NOTE
Each set of hose connectors consists of a nut (see Figure 56, A), a nozzle (B) and a ferrule (C). Depending on the configuration of the cooling water circuit at the installation location, other connection pieces can be used.

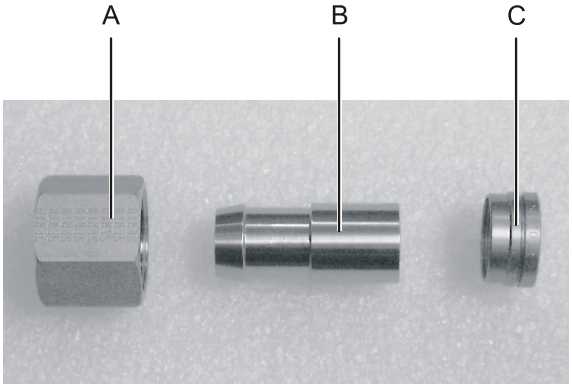

Figure 56: *Set of water hose connectors*

- Length of water hose
- 2 Hose clamps
- Hose cutter
- 17 mm wrench
- Appropriate screwdriver (to tighten hose clamps)
- 2 sets of connectors for connection to water source and drain and, if applicable, appropriate tool to tighten the connectors to the fab

Preconditions

CAUTION
Risk of damaging laser device cooling water circuit!
The use of incorrect cooling water corrodes the heat exchanger. Do not use distilled or deionized water!

- Water supply corresponds with the water supply requirements in Section 4.2.4 on page 82.
- Laser device positioned at final installation location

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Preparation

1. Cut the water hose to the lengths required for the individual water inlet and water outlet lines (hoses).
2. Insert a nozzle into one of the water hoses in the direction indicated in Figure 57.

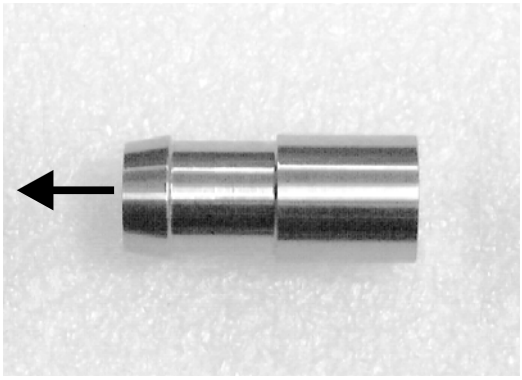

Figure 57: *Insertion of nozzle into water hose*

3. Use a hose clamp to tighten the water hose onto the nozzle.
4. Repeat steps 2 and 3 to prepare the other hose.
5. Remove the protective caps from the water connections on the laser device.

Connecting the Water Lines

NOTE
After tightening the nut on the hose onto the fitting on the laser device, the ferrule is formed in such a way that the nut, nozzle and ferrule can no longer be disassembled. To check the connection unscrew the nut completely. A distinct deformation (annular bulb) must be visible inside of the nozzle.

6. Slide the nut (Figure 56, A) over the nozzle (B) on to the hose.
7. Slide the ferrule (C) over the nozzle until it reaches its stop.
8. While pressing the nozzle against the water inlet connection fitting tighten the nut until finger tight.
9. Use the 17 mm wrench to turn the nut approx.1½ turns onto the connection on the laser device.
10. Unscrew the nut to allow the nozzle to release the tension.
11. Tighten the nut once again until finger tight and use the 17 mm wrench to tighten the nut by turning ¼ rotation for the final fit.

NOTE
When a pipe is to be connected, perform steps 6 to 11 in the same way, but use the other ferrule and use the cooling water pipe instead of the nozzle.

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12. Connect the other end of the hose to the water source.
    The type of connection depends on the configuration of the water supply.
13. Repeat steps 6 to 12 to fit the second water hose between the connector on the laser device marked “WATER OUT” and the building drain.

Tests and Adjustments

14. Turn on the water supply
15. Check that there are no leaks or blockages and rectify if necessary.
16. Shut off the water supply after successfully completing the leak test.

5.2.10 Connect Signal Lines

Purpose

Connect the control and signal lines to the laser device. This consists of either connecting the handheld keypad or remote computer to the corresponding port on the laser device.

5.2.10.1 Connect the Handheld Keypad

The handheld keypad is an easy and comfortable way of operating the COMPex*Pro* without an additional PC (remote PC).

CAUTION
Risk of data loss!
Menu parameters can be lost when disconnecting the handheld keypad! The laser device must be switched off before disconnecting the handheld keypad from the laser device.

Tools and Materials

- Handheld keypad
- RS232 cable
- Appropriate screwdriver for the RS232 plugs

Preconditions

- Laser device positioned at the final installation location
- Supply lines connected

A0510COMPPRO

Connecting the Handheld Keypad

1. Switch off the laser device.
2. Plug the RS232 cable into the RS232 port on the laser device (see Figure 58).

Figure 58: *Connecting RS232 plug to the laser device*

3. Fasten the screws of the plug.
4. Plug in the other side of the cable into the handheld keypad (see (see Figure 59).

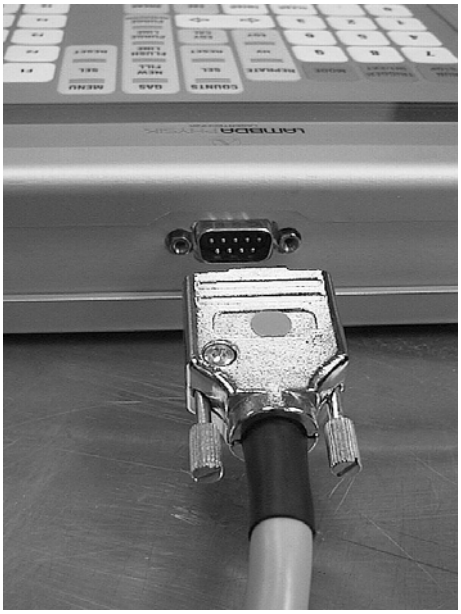

Figure 59: *Connecting RS232 plug to the handheld keypad*

5. Fasten the screws of the plug.

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5.2.10.2 Connect a Remote PC

A remote PC can only be connected when the handheld keypad is disconnected from the laser device.

The remote PC is used to run the COMPex*Pro* through an external program written by the user that communicates with the laser device through the serial interface.

Tools and Materials

- RS232C wire with 25 pin D-type connector (see Section 4.3.8.1 on page 95).
- Appropriate screwdriver for the RS232 plugs

Preconditions

- Laser device positioned at the final installation location
- Supply lines connected

Connecting the Remote PC to the Laser Device

1. Connect the RS232 cable to the laser device's RS232 port (see Figure 58 on page 129).
2. Fasten the plugs screws at the port.
3. Connect the RS232 cable to a serial port on the Remote PC.
4. Fasten the plugs screws at the port.

5.2.11 Leak Test and Passivate Laser Gas Lines

Purpose

Test the gas lines for leaks. After a successful leak test, clean the gas system and passivate the halogen gas line. The sequence in which this procedure has to be executed is:

– evacuate the gas lines and test for underpressure leaks

– fill the gas supply system with inert gas (helium)

– clean the excimer laser gas lines

– passivate the halogen gas line and internal gas system.

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Tools and Materials

- 4-mm allen key
- Helium leak tester or liquid leak tester (e.g. SNOOP®)

NOTE
Make sure that the chosen leak tester is suitable for use in the environment in which the laser is installed. Liquid leak testers are, for instance, not permitted in cleanrooms.

- Ethanol and cleaning paper (when SNOOP® was used)

CAUTION
Incorrect handling can cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas supply system, pressures below 20 bar (abs.) may be critical.

- Gases as specified in Section 4.2.2 on page 76
  Gas cylinders with a remaining pressure of at least 10 bar (abs.)

Preconditions

- Laser device fully installed
- Pressure regulators and cylinder valves in all gas lines closed

NOTE
The handling of pressure regulators and gas cylinder valves is described in Section 6.2.2 on page 150. Depending on the configuration of the gas supply system, a shut-off valve situated between pressure regulator and laser device may be used to open and close the gas lines. The gas lines up to the shut-off valve have to be checked for leaks before starting this procedure.

Preparation

1. Switch on the laser device (see Section 6.2.3 on page 153).

Checking for Vacuum Leak Tightness

CAUTION
Incorrect operation can damage the pressure regulator!
If pressure is applied to a pressure regulator with low secondary pressure, the pressure regulator membrane may become damaged. Always ensure that the pressure regulator is closed, before opening the gas cylinder valve.

2. Ensure that the pressure regulators and cylinder valves are closed on all gas lines.

A0510COMPPRO

3. Open the inert gas cylinder valve.
4. Set the pressure regulator in the inert line to at least 4 bar (abs.).

NOTE
The pressure regulator has to be set to at least 4 bar to completely evacuate the line between the gas cylinder valve and the laser head. With lower pressure settings, residues may remain in the line between the pressure regulator and the gas cylinder valve.

5. Close the inert gas cylinder valve.
6. Press <FLUSH LINE> on the handheld keypad.
   "FLUSH: *current selection* (INERT, BUFFER, RARE, HAL.)" appears in the bottom line of the display.
7. Press <Cursor Right> and/or <Cursor Left> to select INERT.
8. Press <ENTER> to confirm the selection.
9. Press <EXE> to evacuate the selected gas line.
   The message "FLUSH: I.L." appears in the bottom line of the display.

   The vacuum pump runs for two seconds to evacuate the gas line.
10. Repeat step 9 until the pressure regulator gauge indicates a relatively constant vacuum.

NOTE
If a vacuum is not reached there is a relatively large leak in the gas line. Check all connections in the line. If necessary, tighten the connections and repeat the evacuation of the gas line.

11. After appoximately 10 minutes, check the pressure regualator gauge again. A significant increase in pressure indicates a leak.
12. If there is a leak; check and, where necessary, tighten the line connections. Following this, repeat the vacuum leak test.
13. Close the pressure regulator in the inert gas line.
14. Repeat steps 3 to 13 for all other gas lines.

Checking for Overpressure Leak Tightness

15. Ensure that the pressure regulators and cylinder valves are closed on all gas lines.
16. Open the inert gas cylinder valve.
17. Set the pressure regulator in the inert gas line to the specified value (see Section 4.2.2 on page 76).
18. Press <PURGE LINE> on the handheld keypad.
    "PURGE: *current selection* (INERT, BUFFER, RARE, HAL.)" appears in the bottom line of the display.
19. Press <Cursor Right> and/or <Cursor Left> to select INERT.
20. Press <ENTER> to confirm the selection.

A0510COMPPRO

21. Press <EXE> to purge the selected gas line.
    The message ”PURGE: I.L.“ appears in the bottom line of the display.

    The inert gas line and the internal gas system are evacuated and filled with inert gas (He).

NOTE
Depending on the configuration of the gas system, the command has to be repeated until the gas line is completely purged.

22. Remove the service cover from the service side of the laser device.
23. Use a leak tester to check the inert gas line and internal gas system for leaks.
24. If there is a leak; check and, where necessary, tighten the line connections. Following this, repeat the vacuum leak test.
25. Repeat steps 17 to 24 (without leak testing the internal gas system) for all other gas lines.
26. Close the service cover.

Cleaning and Filling the Gas Lines

27. Ensure that the cylinder valves of all gas lines are open and that the pressure regulators are set to the required values (see Section 4.2.2 on page 76).
28. Press <FLUSH LINE> on the handheld keypad.
    “FLUSH: *current selection* (INERT, BUFFER, RARE, HAL.)” appears in the bottom line of the display
29. Press <Cursor Right> and/or <Cursor Left> to select INERT.
30. Press <ENTER> to confirm the selection.
31. Press <EXE> a number of times to clean the inert line.
    The line is evacuated and at the same time refilled with fresh gas.
32. Repeat steps 28 bis 31 for all other gas lines, except the HALOGEN gas line.

Re-passivating the Halogen Gas Line

33. Repeat steps 28 bis 31 for the halogen gas line.
34. Leave the halogen gas in the gas line for approx. 15 minutes.
35. After waiting approx. 15 minutes, press <EXE> again to fill the halogen line with fresh gas.

NOTE
Depending on the configuration of the gas system, the command has to be repeated until the gas line is completely filled.

Finalization

36. When SNOOP® was used, clean the gas line connections with ethanol and wipe dry with cleaning paper.

A0510COMPPRO

5.2.12 Leak Test Laser Tube

Purpose

The window exchange procedure is used to check the leak tightness of the laser tube.

Tools and Materials

CAUTION
Incorrect handling can cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas supply system, pressures below 20 bar (abs.) may be critical.

- Gases as specified in Section 4.2.2 on page 76
  Gas cylinders with a remaining pressure of at least 10 bar (abs.)

Preconditions

- Laser device switched on and laser ready to operate (laser radiation not being emitted)
- Leak tightness of the gas supply system checked
- Gas cylinder valves open and pressure regulator set (see Section 4.2.2 on page 76)

Leak Testing the Laser Tube

1. Press the MENU key <SEL>.
   A shortened version of the current gas menu will be displayed.
2. Check that the settings in the gas menu correspond with the settings on the test sheet.
   If necessary, change the menu or amend the settings (see Section 6.4.2 on page 166).
3. Press <PURGE RESERVOIR>.
   The bottom line of the hand-held keypad display indicates the available options.
4. Press cursor left or cursor right to select “WIN. EXCHANGE”.
5. Press <ENTER> to confirm the choice.
6. Press <EXE> to start the procedure.
   The laser tube is evacuated and then filled to 1200 mbar with inert gas. The inert gas valve then closes. Following this, the message ”REPLACE WINDOWS (enter)“ appears.

A0510COMPPRO

7. Press <ENTER> to start the leak test procedure.

   The laser is filled to 3000 mbar with inert gas and the cavity pressure is monitored over a 15 minute period. During this time the message „LEAK TEST...“ is displayed. If a leak is detected, the message “LEAK TEST...error“ appears. In this case, press <ENTER> to delete the message. Following this, the message “CHECK WINDOWS“ appears. Check that the window mounts are correctly tightened (see Section 7.6.1 on page 201) and then press <ENTER> to restart the leak test.

8. When the message “LEAK TEST...ok“ appears, press <ENTER>, to terminate the routine.

   The laser tube is evacuated again and filled to 1050 mbar with laser gas.

5.2.13 Fill Laser Tube (New Fill)

Purpose

The software routine “NEW FILL“ is used to evacuate the laser tube and fill it with fresh laser gas (see Section 7.5.1 on page 192). After this 2nd new fill, the laser is ready to operate.

NOTE
If, after installation, the beam energy of the COMPex*Pro* is below the specified value, the laser tube has to be re-passivated (see Section 7.5.4 on page 198).

A0510COMPPRO

6 OPERATION

This chapter describes the fundamental operation of the COMPex*Pro*
It is divided into the following sections:

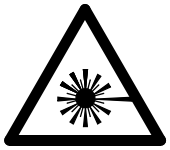
– Section 6.1 provides an overview of the operating and display elements. These are situated on the operating panel (see page 138), or handheld keypad (see page 140).

– Section 6.2 (see page 148) describes the individual routine operating sequences. This includes the procedures to start and stop the laser device or laser.

– Section 6.3 (see page 160) describes the procedures that enable modes or operating parameters to be changed through input at the handheld keypad.

– Section 6.4 (see page 165) describes functions that assist with the set-up and service of the laser device.

NOTE
The prerequisite for performing the procedures described in this chapter is the correct installation and regular maintenance of the laser device.



WARNING
Risk of injury through laser radiation!
The COMPex*Pro* excimer laser device is a Class IV laser product. Avoid eye or skin exposure to direct or scattered laser radiation.

Pay attention to electrical and laser safety before you start operation (see Section 3.2 on page 44).

If the laser device shows any indication of defects, immediately switch off the laser device and solve the problem before starting the laser device again.

A0510COMPPRO

6.1 Operating and Display Elements

This section provides an overview of the operating and display elements on the laser device, operating panel and handheld keypad. The use of these elements in individual operating sequences is described in Section 6.2 on page 148.

6.1.1 Operating Panel

The operating elements that start up and shut down the COMPex*Pro* laser device are located on the operating panel at the rear of the laser head (see Figure 60). These operating elements are described in the following subsections.

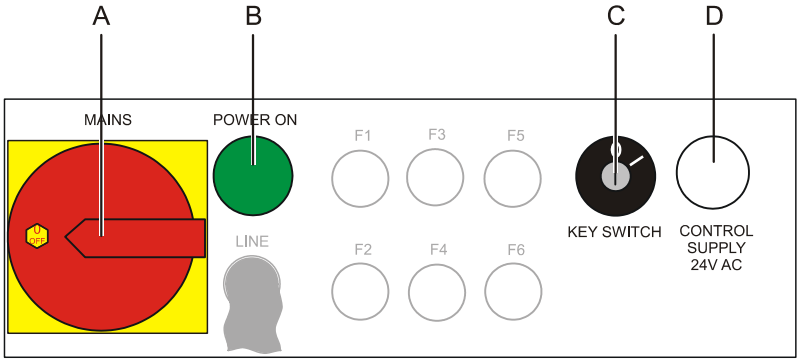


Figure 60: *Operating panel*

Key to Figure 60:

A Main switch
B Power ON lamp
C Key switch
D Control voltage lamp

6.1.1.1 Main Switch

Set the main switch to “ON” to apply line voltage to the laser device. The mains voltage is the operating voltage of certain consumers in the laser device (e.g. thyratron).

The laser cannot, however, be started until the control voltage is activated through the key switch.

Set the main switch to “OFF” to disconnect the laser device from the mains power supply.

A0510COMPPRO

6.1.1.2 Power ON Lamp

The POWER ON lamp indicates that line voltage is applied to the laser device. When this lamp is illuminated, the control voltage circuits in the laser device can be enabled by actuating the key switch.

6.1.1.3 Key Switch

Insert the key into the key switch and set to “I” to activate the control voltage. The control voltage is required for the control modules in the laser device (e.g. basic module and communication interface).

Prior to enabling the control voltage, the main switch has to be set to “ON”.

Set the key switch to “O” to disable the control voltage power.

CAUTION
Prevent injury or damage through unauthorized operation!
Always remove the key from the key switch and keep in a safe place when the laser device is not to be operated.

NOTE
The key cannot be removed from the key switch in the I setting.

6.1.1.4 Control Voltage Lamp

The CONTROL SUPPLY 24V AC lamp indicates that the control voltage has been activated. When the lamp lights, the control modules in the laser device are ready to operate.

6.1.2 Laser Radiation Warning Lamp

The laser radiation warning lamp (see Figure 61, A) is a white lamp that is situated in a clearly visible location on top of the laser device..

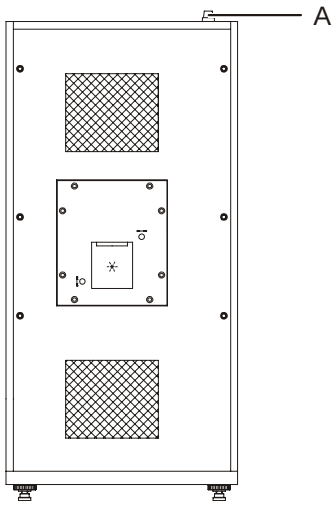


Figure 61: *Laser radiation warning lamp*

This lamp illuminates to indicate that the laser is operating; i.e. laser radiation is being emitted.

For safety reasons, the lamp is visible when wearing excimer laser eye protection and will illuminate approx. 2 seconds prior to starting laser operation.

6.1.3 Handheld Keypad

The handheld keypad (see Figure 62) controls the laser through the communication interface. It consists of a LCD display and membrane keyboard.

NOTE
The operating elements on the handheld keypad are briefly described in the subsections indicated in the Key to Figure 62. For further information regarding the specific use of the keys within particular procedures, please refer to corresponding section in this manual.

A0510COMPPRO

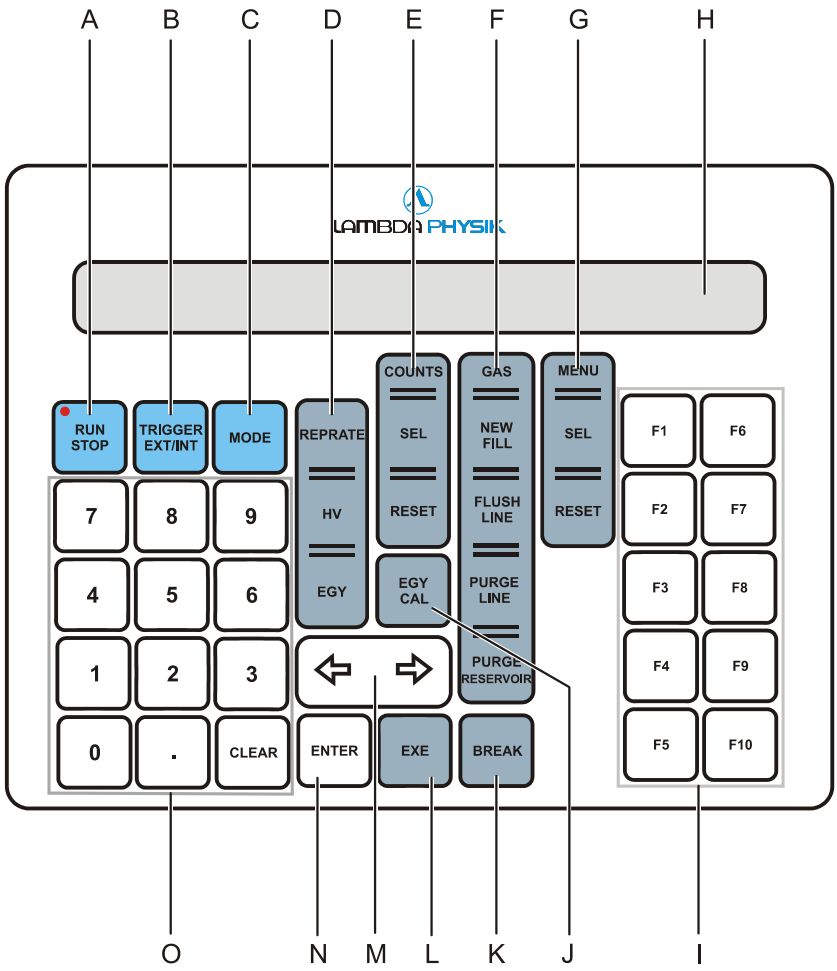


Figure 62: *handheld keypad*

Key to Figure 62

A	RUN STOP key	(see Section 6.1.3.7 on page 144)
B	TRIGGER INT EXT key	(see Section 6.1.3.8 on page 144)
C	MODE key	(see Section 6.1.3.9 on page 145)
D	REPRATE / HV / EGY keys	(see Section 6.1.3.10 on page 145)
E	COUNTS keys	(see Section 6.1.3.11 on page 146)
F	GAS keys	(see Section 6.1.3.15 on page 148)
G	MENU keys	(see Section 6.1.3.12 on page 146)
H	Display	(see Section 6.1.3.1 on page 142)
I	Function keys	(see Section 6.1.3.14 on page 147)
J	EGY CAL key	(see Section 6.1.3.13 on page 146)
K	BREAK key	(see Section 6.1.3.6 on page 143)
L	EXE key	(see Section 6.1.3.5 on page 143)
M	Cursor keys	(see Section 6.1.3.3 on page 143)
N	ENTER key	(see Section 6.1.3.4 on page 143)
O	Numerical input keys	(see Section 6.1.3.2 on page 143)

A0510COMPPRO

6.1.3.1 Display

LCD-display with 2 rows and 40 columns that indicates the current status and parameter settings of the laser as well as displaying prompts and error messages. Figure 63 shows a typical screen display that appears after powering up the laser device when the HV constant mode (HV CONST) and internal triggering are active.

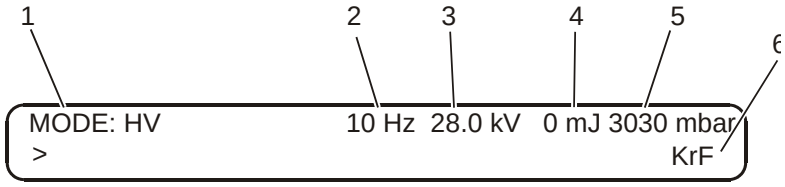


Figure 63: *Status and parameter settings display*

Key to Figure 63:

A Currently active operating mode (laser status) and status code[a]
B Running mode
C Repetition rate (internally set)
D Currently active charging voltage
E Currently emitted beam output energy[b]
F Laser tube pressure
G Gas mixture (gas menu)

a. For more information about the meaning of status codes for basic troubleshooting see Section 8.2.4 on page 270.
b. In the HV CONST mode the current value measured by the energy monitor is displayed. In the energy constant mode (EGY CONST), the set energy constant value is displayed.

After pressing one of the keys that enables a parameter setting to be changed (e.g. the MODE key), a prompt will appear in the bottom row of the display. Depending on the prompt, use the cursor buttons (right and left) to choose one of the items displayed in parenthesis or use the numerical input keys to enter a numerical value.

A0510COMPPRO

6.1.3.2 Numerical Input Keys

The numerical input keys (0 to 9 and decimal point) allow you to enter the numerical values that define parameters such as REPRATE (repetition rate), HV (charging voltage) and EGY (beam output power). The input is confirmed by pressing the ENTER key.

Incorrect entries can be terminated prior to pressing ENTER, by pressing the CLEAR key.

If the entered value is out of range, an audible warning occurs and the last accepted value is retained.

6.1.3.3 Cursor Keys

The cursor keys (cursor left, cursor right) allow you to select a menu item, i.e. one of the items displayed in parenthesis in the bottom line of the display. Press the cursor key that moves the cursor in the direction of the required item and then press ENTER to confirm the selection.

6.1.3.4 ENTER Key

The ENTER key is to be pressed to confirm numerical input or menu items selected with the cursor keys.

6.1.3.5 EXE Key

The EXE (Execute) key is to be pressed to immediately start execution of the last selected function.

6.1.3.6 BREAK Key

The BREAK key is to be pressed to abort the currently active operation. Any unsaved changes will be lost.

If BREAK is pressed during laser operation, the laser immediately stops. Pressing BREAK during a gas action will immediately terminate the action.

BREAK can also be pressed during data input or menu item selection to terminate the action. In this case, the previously active setting is retained.

BREAK is to be pressed twice to clear an interlock after rectifying the reason for the interlock.

A0510COMPPRO

6.1.3.7 RUN STOP Key

The RUN STOP key starts and stops laser operation (emission of laser radiation) and prepares the laser device for shut down.

– When the laser is off (no radiation being emitted but laser device powered up), press RUN STOP to start laser operation or shut down the laser device. After pressing RUN STOP, a menu appears allowing you to *RUN* or *SHUTDOWN*. In each case, use the cursor keys to select the desired mode, confirm the selection with ENTER and press EXE to execute the selection.

  After selecting *ON* and pressing EXE, laser operation is automatically started in the Warmup mode. In the warmup mode, the laser is ramped up to obtain optimum performance. After completing the warmup, the laser automatically starts with the previously active operating parameters (see Section 6.3 on page 160). Emission of laser pulses is indicated by a red LED that lights in the corner of the key and the illuminated laser radiation warning lamp on top of the laser head.

  After selecting *SHUTDOWN*, press EXE to save the current parameter settings onto the industrial computer hard disk prior to shutting down the laser device. While the settings are being saved, the message “Do not switch mains off during shut down!” appears. When the settings have been saved, the message “ready! SWITCH MAINS OFF” appears.

– When the laser is running, press RUN STOP to immediately stop laser emission.

6.1.3.8 TRIGGER INT EXT Key

The TRIGGER INT EXT key allows you to change between the internal and external trigger modes

– With internal triggering, laser pulses are triggered by the laser device’s internal trigger generator.

– With external triggering, laser pulses are triggered from an external trigger generator connected to the external trigger socket on the laser head.

After pressing TRIGGER INT EXT, the desired mode is selected with the cursor keys and confirmed by pressing the ENTER key.

A0510COMPPRO

6.1.3.9 MODE Key

The MODE key allows you to select the desired running mode (see Section 2.7 on page 31).

- HV selects the HV constant mode. In this mode, the high voltage remains constant. Consequently, the beam energy will slowly decrease during operation as the laser gas deteriorates.
- EGY PGR selects the energy constant mode with partial gas replacements. In this mode, the beam energy is kept constant by continuously increasing the high voltage (HV) to compensate for the deterioration of the laser gas. When the HV reaches a preset replacement value, the gas in the laser tube is replenished and the HV value is correspondingly reduced.
- EGY NGR selects the energy constant mode without partial gas replacements. When the HV has reached a given level, a message appears indicating that the gas in the laser tube requires replacing.

6.1.3.10 REPRATE / HV / EGY Keys

The keys REPRATE, HV and EGY allow you to change the repetition rate, charging voltage and beam output energy value.

- REPRATE enables the repetition rate to be changed for internally triggered laser operations. The repetition rate determines the number of laser pulses per second, i.e. the value is specified in Hz.
- HV enables the charging voltage to be set for laser operation in the HV constant mode. Pressing the HV key when an energy constant mode is currently active will display the HV value at which a partial gas replacement occurs.
- EGY enables the beam output energy value to be set for operations in the energy constant mode. The value is entered in mJ.

In each case press the appropriate key to select the parameter to be changed (REPRATE, HV or EGY), enter the value through the numerical input keys and confirm the input by pressing ENTER.

A0510COMPPRO

6.1.3.11 COUNTS Keys

The COUNTS keys enable you to display and reset the laser device's pulse counters.

- SEL indicates the current reading of the Total Counter or the resettable User Counter:
  - The Total Counter counts the total number of laser pulses emitted by the laser since commissioning.
  - The User Counter counts the number of laser pulses emitted since the last counter reset.

  After pressing COUNTS SEL, The desired counter is selected with the cursor keys and confirmed by pressing the ENTER key.
- RESET allows you to reset the User Counter. After pressing COUNTS RESET, the user counter is reset to zero by pressing the EXE key. The Total Counter cannot be reset by the user.

6.1.3.12 MENU Keys

The MENU keys enable you to select or reset the laser device's gas menus.

- SEL allows different gas setting menus to be selected. If the COMPex*Pro* is only to be operated with one gas mixture, this key has no function.
- RESET allows you to reset the values in the gas settings menu (gas partial pressures, gas mode, repetition rate and energy filter) to their factory settings. After pressing MENU RESET, the gas settings are reset to their factory settings by pressing the EXE key.

6.1.3.13 EGY CAL Key

The EGY CAL key selects a routine that allows the internal energy monitor to be calibrated according to an externally measured energy reading.

NOTE
The internal energy monitor is calibrated in the factory. Subsequent calibration is a maintenance procedure that is only to be carried by correspondingly authorized and trained personnel.

A0510COMPPRO

6.1.3.14 Function Keys

The function keys F1 to F10 allow various laser operating or display functions to be selected. As the COMPex*Pro* shares the same handheld keypad and control software with other laser devices, certain function keys are without function for the COMPex*Pro*.

NOTE
Function keys that are only intended for Service purposes are password protected.

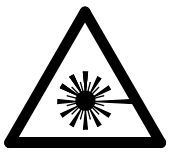
- F1: displays information about active interlocks.
- F2: switches off the low light function when the laser is off (not emitting radiation) or skips the warm-up period when the laser is in the warm-up phase.
  These password protected functions are provided for maintenance and troubleshooting purposes only and should, therefore, only be used by authorized and trained personnel.
- F3: evacuates the laser tube and fills it for re-passivation with a mixture of halogen and helium.
- F4: shows the current filling level of the halogen filter.
- F5: switches the laser tube temperature regulation on or off.
  This password protected function is provided for maintenance and troubleshooting purposes only and should, therefore, only be used by authorized and trained personnel
- F6: flushes the laser tube with the gas connected to the INERT connection. The function is to be called in case of a tube leakage to prevent ambient air from penetrating into the laser tube.
- F7: without function
- F8: switches between “single gas” and “gas premix” operation.
- F9: without function
- F10: acivates the CHARGE ON DEMAND (COD) function. When this function is active, high voltage will only be available when a trigger signal is applied.

6.1.3.15 GAS Keys

The GAS keys allow various gas actions to be carried out. These gas actions are primarily required for maintenance purposes and should, therefore, only be carried out by correspondingly authorized and trained personnel.

- NEW FILL enables the program routine to be started that replaces the gases in the laser tube with fresh gas. The execution of the new fill procedure is described in detail in Section 7.5.1 on page 192.
- FLUSH LINE enables the program routine to be started that evacuates a specific gas line for two seconds. After pressing FLUSH LINE, a prompt appears indicating the currently selected gas line and displaying the further choices in parenthesis. A different gas line is selected with the cursor keys and confirmed by pressing ENTER.
- PURGE LINE enables the program routine to be started that evacuates a specific gas line for five seconds before filling the line with the gas connected to the inert gas connection. After pressing PURGE LINE, a prompt appears indicating the currently selected gas line and displaying the further choices in parenthesis. A different gas line is selected with the cursor keys and confirmed by pressing ENTER.
- PURGE RESERVOIR enables the program routine to be started that purges the laser tube. This routine is required for various maintenance work on the laser tube.

6.2 Routine Operating Sequences



WARNING
Risk of injury through laser radiation!
The COMPex*Pro* excimer laser device is a Class IV laser product. Avoid eye or skin exposure to direct or scattered laser radiation. Section 3 (“Safety”) shall have been read and understood before starting laser operation.

This section describes the routine operating sequences for the COMPex*Pro* excimer laser device. It assumes operation of the laser through the handheld keypad.

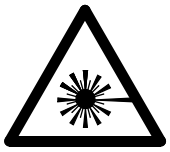
NOTE
A) The terms “laser” and “laser device”, as used in this section, are defined in Section 1.3 on page 6.
B) Before starting to operate the COMPex*Pro*, familiarize yourself with the layout and operation of the laser control program.

A0510COMPPRO

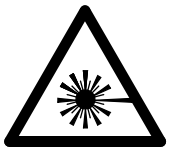
6.2.1 Check Beam Path

Purpose

Ensure that the laser beam will be safely guided to the intended target.



WARNING
Uncontrolled direct or diffuse reflection of the laser beam can cause serious injury!
Ensure that there are no reflective objects or particles in the path of the laser beam.



CAUTION
Risk of fire or release of fumes!
Ensure that there are no materials in the path of the laser beam which may ignite or emit fumes when subject to laser radiation.

NOTE
Utmost safety is provided by completely shielding the beam path (e.g. through a protective enclosure or protective tubes). When the beam path is not to be shielded; keep the beam, wherever possible, in a single plane. Avoid directing the beam at head height.

Tools and Materials

- None

Preparation

1. Fully familiarize yourself with the information about ultraviolet light and ultraviolet radiation safety in Sections 3.2.1.1 and 3.2.2.1 of this manual.

Procedure

2. Shielded beam path:
   Ensure that all shields are correctly installed, i.e. there is no risk of unwanted beam emission.
3. Unshielded beam path:
   Ensure that there are no persons, reflective objects or objects which can ignite and/or emit fumes in the beam path.
4. Secure the beam path and vicinity of the beam path against entry of persons.

A0510COMPPRO

6.2.2 Turn On Gases

NOTE
This section describes gas handling for a straight-forward one gas source for one laser device system. The COMPex*Pro* may, however, connected to an external gas handling system that serves a number of consumers. For exact information about operating the gas handling system, please refer to the system supplier's instructions

Purpose

WARNING
Health hazard through halogen gas leakage!
To minimize the risk of gas leaks, keep the gas cylinder valves closed except when the currently active operating mode or working action requires the external supply of gas.

Turn on the externally supplied gases. We differentiate between excimer laser gases and the purge gas:

– The excimer laser gases are required for laser operation. The gases are to be turned on when running the laser in the energy constant mode (EGY CONST) or when performing a new gas fill or other gas action (e.g. purge laser tube prior to a window exchange).

– The purge gas purges the beam path within the laser device. This is necessary to prevent the formation of ozone when operating the laser at wavelengths shorter than approx. 240 nm (i.e. 193 nm). At longer wavelengths, purging the beam path serves to minimize optic contamination.

NOTE
The purge gas (nitrogen) is to be turned on at least 5 minutes before starting laser operation.

Tools and Materials

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Gases as specified (see Section 4.2.2 on page 76), Gas cylinders with a remaining pressure of at least 10 bar (abs.)

Preconditions

- Gas cylinders connected to the appropriate connectors on the laser device.

A0510COMPPRO

Turning On the Gases

CAUTION
Incorrect operation can damage the pressure regulator!
If pressure is applied to a pressure regulator with low secondary pressure, the pressure regulator membrane may become damaged. Always ensure that the pressure regulator is closed, before opening the gas cylinder valve.

1. Turn the valve on the pressure regulator (see Figure 64, A) of the first gas line counter-clockwise to its stop to ensure that the pressure regulator is closed.

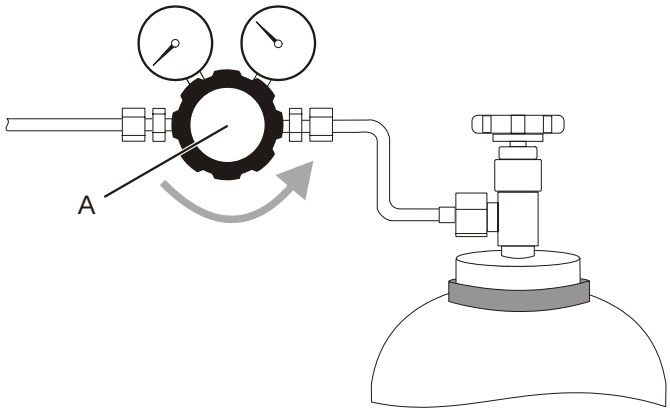


Figure 64: *Closing pressure regulator*

2. Open the valve on the gas cylinder (see Figure 65, A) by turning counter-clockwise.

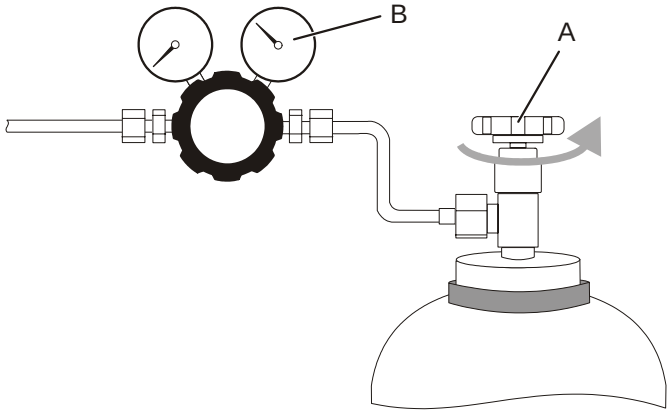


Figure 65: *Opening gas cylinder valve*

3. Check the pressure gauge (see Figure 65, B) indicating the pressure in the gas cylinder to ensure that there is a remaining cylinder pressure of at least 10 bar (abs.).

A0510COMPPRO

4. Turn the valve on the pressure regulator (see Figure 66, A) clockwise until the pressure gauge (B) indicates the required pressure.

NOTE
The required pressures for the individual gases are indicated in Section 4.2.2 on page 76.

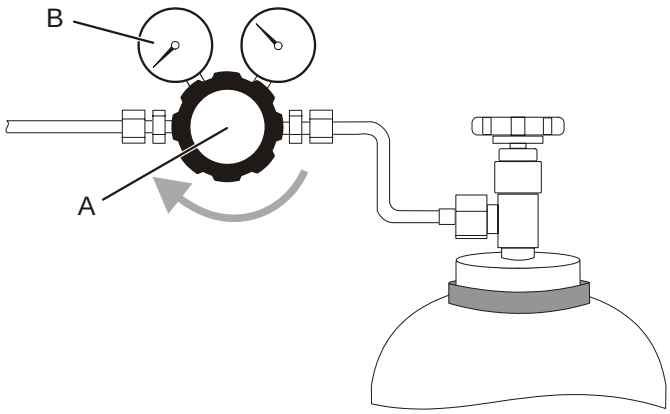


Figure 66: *Setting pressure regulator to required pressure*

5. Repeat steps 1 to 4 to turn on each of the other gases connected to the laser device.

A0510COMPPRO

6.2.3 Start-Up Laser Device

Purpose

Start-up the laser device to enable laser operation. The device starts with a self-test of the data ring and laser modules and the warming-up of the thyratron.

Tools and Materials

- None

Preconditions

- Laser device ready to operate (e.g. device correctly connected to the electricity, gas and water supplies and linked to the laser assembly or laser unit).
- Beam path checked (see Section 6.2.1 on page 149)
- Where applicable, purge gas turned on for at least 5 minutes (see Section 6.2.2 on page 150).
- Externally supplied excimer laser gases turned on if gas actions are required (see Section 6.2.2 on page 150).

Preparation

WARNING
Risk of serious injury!
Ensure that only authorized and trained personnel operate the laser device.

1. Check the maintenance schedule.
2. Where applicable, turn on the cooling water (see Section 4.2.4 on page 82 for the cooling water specifications).

A0510COMPPRO

Turning-On the Laser Device

3. Turn the main switch (see Figure 68, A) clockwise to the ON setting. The POWER ON lamp (B) lights and various consumers in the laser device will start.

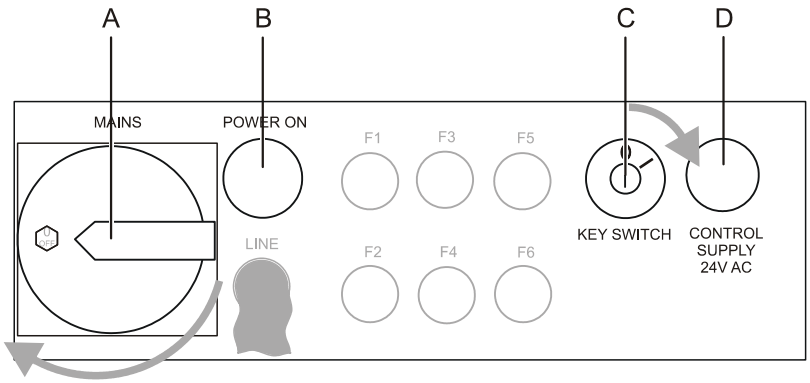


Figure 67: *Switching on the laser device*

4. Insert the key into the key switch (see Figure 67, C) and turn clockwise to the I setting to activate the laser controller.

   The CONTROL SUPPLY lamp (D) lights.

   The laser device performs a self-test.
   If a serious malfunction is detected during the self test, “FATAL ERROR“ will appear in the 2nd line of the handheld keypad display.

   After successfully completing the self-test, the laser is warmed-up for a period of 8 minutes. During this period ”WARMUP XX min“ is displayed (”XX“ indicates the remaining warm-up time in minutes).

   During the warm-up phase, no laser light can be emitted. Checking and maintenance actions that do not require laser emission can, however, be carried out. These actions include:

   – checking parameter settings (see Section 6.3 on page 160).
   – flushing/purging the gas lines (see Section 7.4 on page 179).
   – exchanging the laser gas (see Section 7.5.1 on page 192).

   After completing the warm-up phase, the laser is ready to operate (see Section 6.2.4 on page 155).

A0510COMPPRO

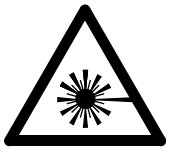
6.2.4 Start Laser Operation

Purpose

Switch on the laser beam to commence lasing using the currently set operating parameters. To enable generation of the laser beam, the high voltage circuit is activated.

NOTE
If the laser device has water cooling without the optional temperature regulation, the cooling water flow has to be set in accordance with the water inlet temperature before starting normal laser operation.

Tools and Materials



WARNING
Risk of eye injury!
Always wear appropriate laser protective eyewear when working on or with an open (i.e. unprotected) excimer laser beam (see Chapter 3).

- Appropriately rated laser protective eyewear

NOTE
Protective eyewear is not necessary when the COMPex*Pro* is part of a laser unit with a completely sealed beam path (for further information, please refer to the laser unit supplier's documentation).

- Thermometer with scale from 0 °C to 50 °C (32 °F to 122 °F)

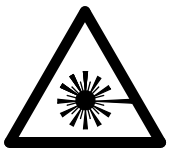
Preconditions

- Beam path correctly shielded or secured to ensure that the laser beam will be safely guided to the intended target (see Section 6.2.1 on page 149).
- Laser device started-up and ready to emit laser radiation (see Section 6.2.3).
- Handheld keypad connected to the communication interface socket on the laser device.

Preparation

1. When working with an open laser beam, take off your watch, ring or any other jewelry which could cause reflections that divert the laser beam from the intended path
2. Ensure that the operating parameters displayed in the top line of the handheld keypad display are correct for the laser operating sequence that is to be started.

Starting the Laser



WARNING
Risk of injury through laser radiation!
When working on or with an open (i.e. unprotected) excimer laser beam, always wear appropriate laser protective eyewear. Do not wear reflective jewelry such as rings or watches. Read the safety instructions in Section 3 before starting the laser.

3. Open the beam shutter.
4. Press <RUN/STOP> (see Figure 68, A).

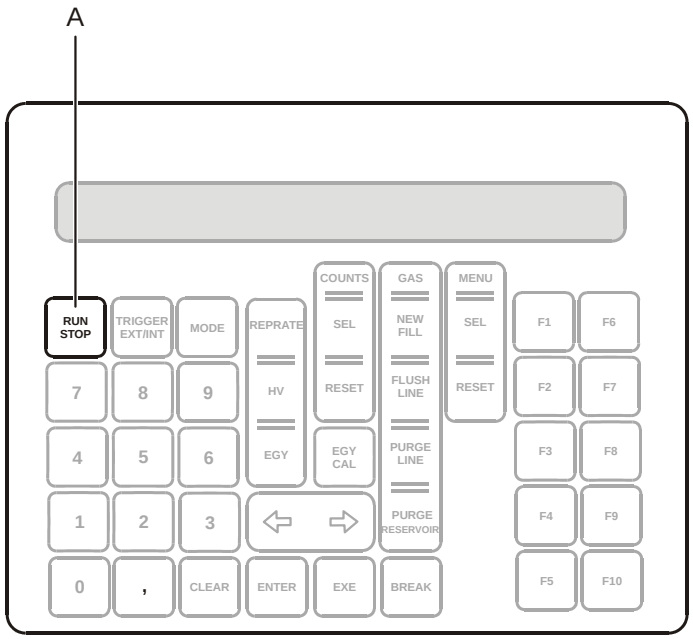


Figure 68: *RUN / STOP key on the keypad*

After a short delay to initialize the power supply, the laser radiation warning lamps light. Laser light pulses are emitted at the given repetition rate. This can be recognized by an audible clicking.
If the laser does not start, the power supply was unable to be initialized. In this case, switch the laser device off and then on again and attempt to restart the laser. If the problem persists call service.

Adjusting the Cooling Water Flow Rate

5. Start laser operation for about 1000 shots to warm up the laser tube.
6. Measure the water outlet temperature. It must be within 25 °C to 30 °C (77 °F to 86 °F) for there to be a laser tube temperature of 30 °C to 38 °C (86 °F to 100 °F).
7. Adjust the flow rate according to the water temperature.
   The flow rate is to be 1 to 5 l/min, depending on the water temperature.

A0510COMPPRO

6.2.5 Stop Laser Operation

Purpose

Stop the laser for longer processing interruptions and prior to shutting-down the laser device.

NOTE
For short interruptions in the processing sequence, the manual shutter can be closed. To maximize the lifetime of the modules in the laser device, the laser should be switched off during longer processing interruptions.

Tools and Materials

- None

Preconditions

- Laser switched on (laser radiation being emitted)
- Handheld keypad connected to the communication interface socket on the laser device.

Stopping the Lasers

1. Press the <BREAK> key twice (see Figure 69, A) to stop the laser.

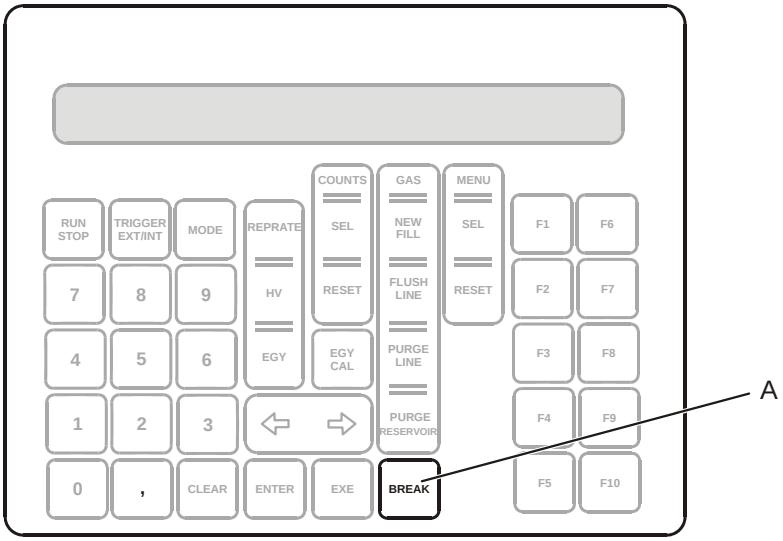


Figure 69: *BREAK key on the keypad*

2. Close the beam shutter.

NOTE
The <RUN/STOP> key can also be used. This will, however, not stop the laser if a command that requires input is active.

A0510COMPPRO

6.2.6 Shut-Down Laser Device

Purpose

Shut down the laser device prior to maintenance or after use.

Tools and Materials

- None

Preconditions

- No laser radiation being emitted (see Section 6.2.5) or other routines (e.g. window exchange) active .

Switching off the Laser Device

1. Turn the key in the key switch (see Figure 67, C on page 154) counter-clockwise to the “O” setting.
   The CONTROL SUPPLY lamp (see Figure 67, D) goes out.

WARNING
Prevent accidents through unauthorized operation!
To prevent unauthorized operation of the COMPex*Pro*, always remove the key from the key switch after shutting down the laser device. Keep the key in a safe place.

2. Remove the key from the key switch and keep in a safe place.
3. Turn the main switch (see Figure 67, A) counter-clockwise to the “OFF” setting.
   The LINE ON lamp (see Figure 67, B) goes out.
4. Where applicable, turn off the cooling water supply at the source.
5. Turn off the gases (see Section 6.2.7).

A0510COMPPRO

6.2.7 Turn Off Gases

NOTE
This section describes gas handling for a straight-forward gas system with one gas source for one laser device. The COMPex*Pro* may, however, be connected to an external gas handling system that serves a number of laser devices. Therefore, for exact operating information, please refer to the gas handling system supplier's instructions.

Purpose

Turn off the excimer laser gases and/or purge gas at the source.

NOTE
A) Turn off all gases when the laser device is to be shut down for longer periods (e.g. overnight).
B) Turn off excimer laser gases when no activities requiring gas activities are to be performed.

Tools and Materials

- None

Preconditions

- None

Turning Off Gases

1. Close the valve on the gas cylinder (see Figure 70, A) by turning it clockwise to its stop.

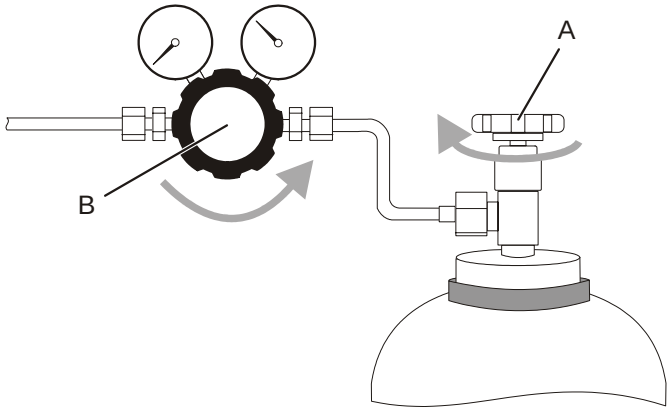


Figure 70: *Shutting down the gas supply*

2. Turn the valve on the gas pressure regulator (see Figure 70, B) counter-clockwise to its stop. This ensures that the pressure regulator is closed.
3. Repeat steps 1 and 2 to turn off the other gases.

6.3 Operating Modes and Parameters

This section describes the selection and setting of operating modes and parameters with the handheld keypad.

NOTE
When the laser device is switched off, the last settings are stored and reactivated when the laser device is restarted. In certain operating modes, these settings will be overridden by default settings. Therefore, before starting the laser, always check the settings of the operating parameters.

Tools and Materials

- None

6.3.1 Change Trigger Mode

Purpose

Switch between external and internal triggering of the laser.

- Internal triggering (INT):
  laser pulses are triggered by the laser device's internal trigger generator. This causes laser pulses to be fired at the preselected repetition rate.
- External triggering (EXT):
  laser pulses are triggered by an external trigger generator connected to the EXT TRIG. socket on the connection side of the laser device (see Section 4.3.8.3 on page 96).

Requirements

- Laser device switched on
- Internal triggering:
  Repetition rate correctly set (see Section 6.3.2)

CAUTION
Risk of damaging laser device!
Do not connect or disconnect the external trigger cable to the EXT. TRIG socket while the laser is running.

- External triggering:
  External trigger generator correctly set and connected to the EXT. TRIG (external trigger) socket on the rear of the laser head.

A0510COMPPRO

Selecting the Trigger Mode

1. Press <TRIGGER INT EXT>.

   The bottom line of the handheld keypad display reads: "TRIGGER= *current selection* (INT, EXT)".
2. Press either <Cursor Right> or <Cursor Left> to select the desired trigger mode.
3. Press <ENTER> to confirm the selection.

6.3.2 Change Repetition Rate

Purpose

Set the repetition rate (rep. rate) for internal triggering of the laser.

NOTE
A) When the laser is operating in the internal trigger mode, the changed repetition rate will become active immediately.
B) The repetition rate can also be changed when the laser is operating in the external trigger mode. In this case, the next internally triggered laser operation will start with the changed repetition rate.

The repetition rate is always indicated in Hz (1/s). Only integers are accepted. The minimum repetition rate is 1 Hz. The maximum repetition rate depends on the COMPex*Pro* version and is indicated on the corresponding data menu page.

Preconditions

- Laser device started up (see Section 6.2.3)

Entering the Repetition Rate

1. Press <REPRATE>.

   The bottom line of the handheld keypad display reads: "REPRATE= *current setting* Hz".
2. Use the numerical input keys to enter the desired value in Hz.
3. Press <ENTER> to confirm the selection.
   The new value will be indicated in the top line of the display.

NOTE
A beep tone will indicate an out of range value. In this case, the previously set value remains active.

6.3.3 Change Running Mode

Purpose

Select the desired laser running (energy management) mode.
The available choices are:

– Energy constant mode with partial gas replacement (EGY PGR)

– Energy constant mode without partial gas replacement (EGY NGR)

– HV constant mode (HV)

The selected running mode will become immediately active and is indicated in the top left corner of the handheld keypad display.

– When the HV constant mode is selected, the currently set charging voltage becomes active.

– When one of the energy constant modes is selected, the currently set beam output energy value becomes active The high voltage value at which a partial gas replacement occurs (HV_{repl} value) can be displayed by pressing the <HV> key.

For further information about energy management modes see Section 2.7 on page 31.

Preconditions

- Laser device switched on
- HV constant mode:
  HV charging voltage correctly set (see Section 6.3.5 on page 164).
- Energy constant mode:
  Beam output energy value correctly set (see Section 6.3.4 on page 163). Gas cylinder valves open and pressure regulators correctly set (see Section 6.2.2 on page 150).

Selecting the Running Mode

CAUTION
Risk of processing wastage!
During a partial gas replacement (EGY PGR) the pulse energy fluctuations are higher than during normal operation. Ensure that the currently active processing application will not be harmed..

1. Press <MODE>.
   The bottom line of the handheld keypad display reads:
   “MODE=*current selection* (HV, EGY PGR, EGY NGR)”.
2. Press <Cursor Right> and/or <Cursor Left> to select the desired running mode.

A0510COMPPRO

3. Press <ENTER> to confirm the selection.
   The selected running mode is indicated in the top left corner of the handheld keypad display

NOTE
The message “PRESET ENERGY TOO HIGH“ appears when a new gas fill is required (see Section 7.5.1 on page 192)

6.3.4 Change Beam Output Energy Value

Purpose

Set the beam output energy value for laser operations in one of the energy constant modes.

NOTE
The beam output energy value cannot be changed when the HV constant mode is selected. The range of possible energy values is indicated in the gas menu (see Section 6.4.2 on page 166).

Preconditions

- Energy constant mode (EGY PGR or EGY NGR) selected (see Section 6.3.3)

Entering the Beam Energy Value

1. Press <EGY>.

   The bottom line of the handheld keypad display reads:
   “EGY= *current setting* mJ”.

NOTE
If <EGY> is pressed when the HV constant mode is active, a beep tone indicates that the selection has been denied.

2. Use the numerical input keys to enter the desired value in mJ.
3. Press <ENTER> to confirm the input.
   The new value appears in the top line of the handheld keypad display.

NOTE
A beep tone will indicate an out of range value. In this case, the previously set value remains active.

A0510COMPPRO

6.3.5 Change Charging Voltage

Purpose

Set the charging voltage for laser operations in the HV constant mode. The largest and smallest permissible high voltage values are determined in the gas menu (see Section 6.4.2 on page 166).

Preconditions

- HV constant mode selected (see Section 6.3.3)

Entering the Charging Voltage

1. Press <HV>.
   The bottom line of the handheld keypad display reads:
   “HV= *current setting* kV”.

NOTE
If <HV> is pressed when one of the energy constant modes is active, a beep tone indicates that the selection has been denied.

2. Use the numerical input keys to enter the desired value in Hz.

NOTE
Input with one digit after the decimal point is permitted.

3. Press <ENTER> to confirm the input.
   The new value appears on the handheld keypad display.

NOTE
A beep tone will indicate an out of range value. In this case, the previously set value remains active.

A0510COMPPRO

6.4 Set-Up and Service

This section describes handheld keypad functions that can be used to change the operational set-up of the laser device or assist with servicing activities.

NOTE
When the laser device is switched off, the last settings are stored and reactivated when the laser device is restarted. In certain operating modes, these settings will be overridden by default settings. Therefore, before starting the laser, always check the settings of the operating parameters.

6.4.1 Select Charge On Demand (COD)

Purpose

Toggle between normal charging and Charge On Demand (COD).

- Normal charging:
  laser pulses are emitted continuously. When the emission of laser pulses is needed in irregular intervals or the repetition rate is very low (e.g. 10 Hz or lower) the storage capacitors remain charged during the stand-by interval between laser pulses. In these stand-by intervals the laser may produce unintended laser pulses (self-firing). Depending on the working application, self-firing may cause severe damage to the target.
- COD:
  prevent self-firing as the thyratron only switches when the pulse is needed. The HV is switched off and the capacitors remain uncharged. When a laser pulse is needed, a trigger signal enables the power supply to charge the storage capacitors. After the storage capacitors are charged, a trigger signal is sent to the thyratron. The laser emits one pulse and HV is switched off again.

  The trade-off is an additional jitter of about 2.5 µs (the typical jitter is only 2 ns).

As COD can be activated or deactivated, the COMPex*Pro* is adaptable to both jitter sensitive applications and those which do not allow additional pulses.

NOTE
Due to the capacitor charging time of 20 ms, COD supports repetition rates only up to 50 Hz. Higher values are automatically replaced with 50 Hz and the message “WARNING! REPRATE FOR COD > 50 HZ” is displayed.

A0510COMPPRO

COD should be used

– to avoid temporary laser stand-by while capacitors are charged that would otherwise cause the laser to self-fire.

– if the repetition rate is less than 50 Hz and jitter as well as delay are not critical.

The COD command can also be used to determine the COD time delay, as it is displayed during selection of the COD.

Preconditions

- Laser device switched on and laser ready to operate (laser radiation not being emitted)

Toggling between COD On and COD Off

1. Press the function button <F10>.
   If the current status is “ON”, the time delay is displayed in µsec. This is the time between trigger signal and laser pulse which is the time the capacitors need to be charged before each laser pulse.
2. Press either <Cursor Right> or <Cursor Left> to select ON or OFF.
3. Press <ENTER> to confirm the selection.
   The COD status is saved. If COD has been switched on, “COD” is displayed on the handheld keypad.

6.4.2 Select and Change Gas Menu

Purpose

Select the gas menu for the gas mixture appropriate to the wavelength at which the laser is to be operated. The gas menu displays the following parameters:

– Menu number,

– Gas mixture,

– Partial pressures (sequentially).

Requirements

- Laser device switched and laser ready to operate (laser radiation not being emitted)

Selecting and Changing the Gas Menu

1. Press the <MENU SEL> key.
   A short form of the current menu will be displayed in the bottom line of the handheld keypad display.
2. Press <Cursor Right> and/or <Cursor Left> to select the number of the desired gas menu.

A0510COMPPRO

3. Press <ENTER> to confirm the selection.
4. Press <ENTER> to choose the next partial pressure.

   The factory settings for the partial pressures are optimized and should only be changed when the gas specifications change. If necessary, the gas menu can be reset to the factory settings (see Section 6.4.3 on page 167).
5. Where necessary, use the numerical keys to enter a new partial pressure.

   The limits for the partial pressures are ± 20 % of the partial pressures defined through the factory settings.
6. Repeat steps 4 and 5 for the next gas components.
7. Press <ENTER> to confirm the settings in the gas menu.
   The laser device will carry out the next new fill on the basis of the revised gas menu data.

6.4.3 Reset Gas Menu to Factory Settings

Purpose

Reset the data in the gas menu to the factory settings. The following values will be changed:

– Partial pressures,

– Gas mode,

– Repetition rate,

– Energy filter.

Requirements

- Laser device switched on and laser ready to operate (laser radiation not being emitted)

NOTE
When the laser is in the OFF mode, this command is only available twice.

Resetting the Gas Menu

1. Press the <MENU SEL> key.
   A short form of the current menu will be displayed in the bottom line of the handheld keypad display.
2. Press <Cursor Right> and/or <Cursor Left> to select the number of the desired gas menu.
3. Press <RESET>.
4. Press <EXE> to reset the gas menu to the factory settings .

A0510COMPPRO

6.4.4 Select Gas Mode

Purpose

Selection between single gas and premix gas mode:

– Single gas mode
  All gas components are connected as single gas cylinders; the partial pressures are mixed by the laser control.

– Premix gas mode
  All gas components are premixed in one gas cylinder.

NOTE
When resetting the gas menu, the gas mode is also reset to the factory setting.

Tools and Materials

- None

Requirements

- Laser device switched on and laser ready to operate (laser radiation not being emitted)

Selecting the Gas Mode

5. Press <F8>.
   The available gas modes appear in the bottom line of the handheld keypad display.
6. Press <Cursor Right> and/or <Cursor Left> to select the gas mode.
7. Press <ENTER> to confirm the selection.

6.4.5 Activate Temperature Control (Optional)

Purpose

Activate the temperature control to enable a given tube temperature to be maintained.

Tools and Materials

- None

Requirements

- Laser device switched on and laser ready to operate (laser radiation not being emitted)

A0510COMPPRO

Activating the Temperature Control

8. Ensure that the cooling water valve is open.
9. Press <F5>.
   The current status of the temperature regulation appears in the bottom line of the handheld keypad display.
10. Press <Cursor Right> and/or <Cursor Left> to select ON or OFF.
11. Press <ENTER> to confirm the selection.

6.4.6 Read Total Counter

Purpose

Obtain the total counter reading to determine the total number of laser pulses emitted by the laser since commissioning.

Preconditions

- None

Reading the Total Counter

1. Press <COUNTS SEL>.
   The bottom line of the handheld keypad display indicates the currently active counter and number of pulses.
2. If necessary, use the <Cursor Left> key to select the total counter reading.
3. Note the counter reading.
4. Press ENTER to cancel the counter reading function.
   The previously active screen display re-appears.

A0510COMPPRO

6.4.7 Read User Counter

Purpose

Obtain the user counter reading to determine the total number of laser pulses emitted since the last counter reset.

Preconditions

- None

Reading the User Counter

1. Press <COUNTS SEL>.

   The bottom line of the handheld keypad display indicates the currently active counter and number of pulses.
2. If necessary, use the <Cursor Right> key to select the user counter reading.
3. Note the counter reading.
4. Press ENTER to cancel the counter reading function.
   The previously active screen display re-appears.

6.4.8 Reset User Counter

Purpose

Reset the user counter reading to zero.

Preconditions

- None

Resetting the User Counter

1. Press <COUNTS RESET>.

   “COUNTER=RESET” appears.
2. Press <EXE> to reset the user counter to zero.

   “EXECUTED” briefly appears to confirm that the user counter has been reset.

A0510COMPPRO

6.4.9 Emergency Fill with Inert Gas

Purpose

An emergency gas fill (“manual fill with inert gas“) fills the laser tube with inert gas for 10 seconds. This is required to fill the laser tube to a pressure higher than atmospheric pressure to protect it (e.g. after a malfunction) for a period from the penetration of ambient air. This function is required:

– when (e.g. due to the interruption of a procedure) the tube pressure has dropped below 1050 mbar,

– when the laser tube has a leak (or a leak is suspected).

NOTE
This function can only be used when an inert gas cylinder is connected to the appropriate gas fitting on the laser head. If an inert gas cylinder is not connected, carry out a transport filling (see Section 7.12.1 on page 250).

Tools and Materials

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Gases as specified (see Section 4.2.2 on page 76), Gas cylinders with a remaining pressure of at least 10 bar (abs.)

Preconditions

- Laser device switched on and laser ready to operate (laser radiation not being emitted)
- Inert gas supply open and pressure regulator set to at least 4 bar (abs.)

Emergency Fill Procedure

1. Press <F6>.
   The bottom line of the handheld keypad display shows the available options.
2. Use the cursor keys to select MANUAL INERT.
3. Press <ENTER> to confirm the selection.
4. Press <EXE> to start the manual fill with inert gas.
   The laser head valve and the inert gas valvle open for 10 seconds and then automatically close. The new pressure will be displayed. If a higher pressure is necessary, repeat step 4.

A0510COMPPRO

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7 MAINTENANCE

This chapter describes the routine maintenance of the COMPex*Pro* laser device. Follow the recommended service intervals and procedures to ensure optimum performance. The necessary maintenance procedures are outlined in a maintenance schedule in Section 7.2 (page 174) before being described in detail in the subsequent sections.

WARNING
Risk of serious injury or damage!
Always switch off the laser device to perform maintenanence, servicing and repair work.
When the laser device switched has to remain switched on to perform maintenance work, always ensure that the maintenance area is adequately secured and marked and that unauthorized persons cannot gain access to the laser device.
All persons in the maintenance area have to be fully familiar with the appropriate sefaty regulations and requirements .

7.1 Laser Logbook

Prepare a laser logbook to keep a continuous record of data relating to laser operations. This simplifies routine maintenance scheduling as well as troubleshooting.

The data recorded in the logbook should provide information about relevant changes in the operating behaviour of the device. The logbook should include the following entries:

– Date and time
– Running mode (HV, EGY PGR, EGY NGR)
– Charging voltage and beam output energy
– Operating mode (OPMODE)
– Trigger mode
– Repetition rate
– Status (Gas actions, warnings, interlocks etc.)
– Counter reading (total counter).

A0510COMPPRO

7.2 Maintenance Schedule

This section contains the periodic and event related maintenance schedule for the COMPex*Pro* laser device. The information is presented in a form that allows the routine maintenance of the laser device to be exactly coordinated with the routine maintenance of other components in the system to which the laser device is connected.

The required intervals and actions differ depending on the version of the laser device.

7.2.1 COMPex*Pro* 100 / COMPex*Pro* 200

Maintenance Interval	Action	Time Required	Comments
- Every 5 to 25 million pulses[a] - Every 1 to 2 weeks[b]	New gas fill	0.5 h	see Section 7.5.1 on page 192
- Before a new gas fill - After a week of non-operation	Flush gas lines	0.1 h	see Section 7.4.1 on page 179
- Every 10 to 30 million pulses - Every 3 to 5 new gas fills	Clean tube optics	1.0 h	See Section 7.6.1 on page 201
- After cleaning the tube windows five times	Renew tube optics	1.0 h	
- Whenever the tube windows have been cleaned / exchanged	Align laser beam	1.0 h	See Section 7.8 on page 232
	Calibrate energy monitor	0.75 h[c]	See Section 7.7.1 on page 223
- With every energy monitor calibration	Clean beam splitter	0.5 h	See Section 7.7.2.1 on page 227
- Every 4 weeks - Before a new gas fill	Check halogen filter level	0.05 h	See Section 7.11.1 on page 246
- When indicated by the laser control software	Replace halogen filter	0.25 h	See Section 7.11.2 on page 246
- Every 300 million pulses	Check / adjust thyratron voltages	0.25 h	See Section 7.10 on page 242
- If pressure in the gas cylinder drops below 10 bar	Change halogen gas cylinder	0.75 h	See Section 7.4.3 on page 182
- When gas cylinder has passed expiry date	Change rare, inert or buffer gas cylinder	0.5 h	See Section 7.4.4 on page 187
- Before transportation - Before storage	Perform transportation fill	0.25 h	See Section 7.12.1 on page 250

a. Typical values for dynamic gas lifetime. XeCl lifetime tends to be greater than the other gases
b. Typical values for static gas lifetime. XeCl lifetime tends to be greater than the other gases
c. Including new gas fill

A0510COMPPRO

7.2.2 COMPex*Pro* F_2

Maintenance Interval	Action	Time Required	Comments
- Every 1 to 5 million pulses[a] - Every 3 to 5 days[b]	New gas fill	0.5 h	see Section 7.5.1 on page 192
- Before a new gas fill - After a week of non-operation	Flush gas lines	0.1 h	see Section 7.4.1 on page 179
- Every 10 to 30 million pulses - Every 3 to 5 new gas fills	Renew tube optics	1.0 h	See Section 7.6.4 on page 214
- Whenever the tube windows have been cleaned / exchanged	Align laser beam	1.0 h	See Section 7.8 on page 232
	Calibrate energy monitor	0.75 h[c]	See Section 7.7.1 on page 223
- With every energy monitor calibration	Clean beam splitter	0.5 h	See Section 7.7.2.2 on page 228
- Every 4 weeks - Before a new gas fill	Check halogen filter level	0.05 h	See Section 7.11.1 on page 246
- When indicated by the laser control software	Replace halogen filter	0.25 h	See Section 7.11.2 on page 246
- Every 300 million pulses	Check / adjust thyratron voltages	0.25 h	See Section 7.10 on page 242
- If pressure in the gas cylinder drops below 10 bar - When gas cylinder has passed expiry date	Change halogen gas cylinder	0.75 h	See Section 7.4.3 on page 182
	Change rare, inert or buffer gas cylinder	0.5 h	See Section 7.4.4 on page 187
- Before transportation - Before storage	Perform transportation fill	0.25 h	See Section 7.12.1 on page 250

a. Typical values for dynamic gas lifetime
b. Typical values for static gas lifetime
c. Including new gas fill

A0510COMPPRO

7.3 Lockout / Tagout

Purpose

This procedure establishes the minimum requirements for the lockout of energy isolating devices whenever maintenance or servicing is performed on the COMPex*Pro* laser device. It shall be used to ensure that the laser device is stopped, isolated from all potentially hazardous energy sources and locked out before employees perform any servicing or maintenance where the unexpected energization or start-up of the laser device or release of stored energy could cause injury.

WARNING
Risk of serious injury!
All employees are required to comply with the restrictions and limitations imposed upon them during the use of lockout. The authorized employees are required to perform the lockout in accordance with the procedures described in this section.
All employees, upon observing a machine or piece of equipment which is locked out to perform servicing or maintenance shall not attempt to start, energize or use that machine or equipment.

The potentially hazardous energy sources of the COMPex*Pro* are:

– High voltage / electric energy

– Laser light

– Compressed gases

To perform maintenance or servicing within the laser device, these hazardous energy sources are isolated by setting the laser device's main switch to the OFF position. When working with an open gas system, e.g. when disconnecting the laser device from the gas supply or working on the gas supply lines (up to and including the solenoid valves), the external gas supply also has to be shut off and locked out / tagged out.

Tools and Materials

- Assigned individual lockout and/or tagout devices suitable for use with the respective energy isolating device.

NOTE
The assigned lockout / tagout device shall correspond with OSHA 29 CFR 1910.147(c)(5), i.e. it is to be durable, of a standardized type within the facility, substantial enough to prevent removal without the use of excessive force or unusual techniques and shall indicate the identity of the person applying the device.

A0510COMPPRO

Securing the Main Switch

1. Notify all responsible persons that the the COMPex*Pro* laser device requires servicing or maintenance and that it must be shut down and locked out to perform the servicing or maintenance.
2. If the laser device is operating, shut it down by following the usual shut down sequence (see Section 6.2.6 on page 158).
3. Ensure that the main switch is set to "OFF" (see Figure 71) so that the laser device is isolated from the potentially hazardous energy sources.

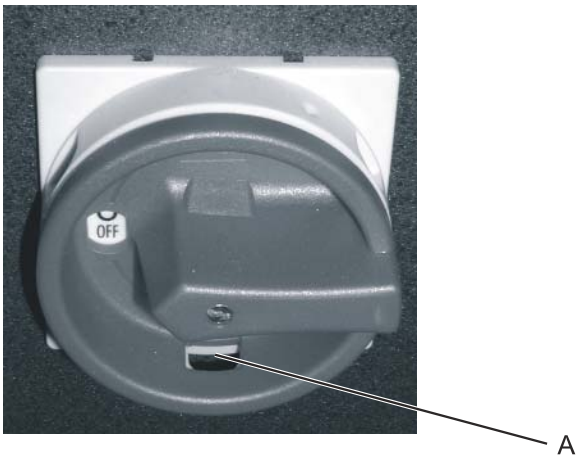

Figure 71: *Main switch lockout*

4. Lockout the main switch by inserting the assigned lockout device into the opening in the bottom of the main switch (see Figure 71, A).

NOTE
The lockout device can only be inserted when the main switch is in the "OFF " position.

5. Dissipate any stored or residual energy by following the specific instructions in the respective service or maintenance procedure; e.g. when working on the HV system (which contains a thyratron), always insert the grounding stick and allow the capacitors to discharge before starting work.
6. Ensure that the laser device is disconnected from the energy source and isolated by turning the key switch and making certain that the laser device will not operate.
7. Depending on local regulations, attach appropriate tags to warn that maintenance or servicing is being performed and indicate the identity of the person who applied the lockout device.

   The main switch of the laser device is now locked out. The necessary maintenance or servicing can now be performed. If, however, work is to be carried out on an open gas system, always perform steps 8 to 11 prior to starting the maintenance or servicing work.

Securing the Gas Supply Lines

NOTE
Steps 8 to 11 are generally applicable when the external gas supply lines are to be isolated to perform work on the COMPex*Pro* excimer laser device. The exact procedure to de-energize and secure the gas supply lines depends on the configuration of the facility's gas supply system and design of the shut off valves.. Always first contact the person authorized to perform the gas system lockout/tagout procedure when work an open gas system is necessary.

8. Notify the responsible persons that servicing or maintenance is required on the COMPex*Pro* laser device and that the gas supply lines leading to the laser device must be shut down and locked out to perform the servicing or maintenance.
9. Turn off the shut off valve (e.g. ball or gate valve) and secure the valve by installing the appropriate valve cover, lock and/or tag.

NOTE
Fluorine gas lines require double valve isolation for maintenance on the gas system.

10. Evacuate the gas lines between the shut off valve and gas manifold in the laser device.
11. Ensure that the appropriate gas pressure gauges indicate a reading of zero before starting the maintenance or servicing.

Restoring the Laser Device to Service

NOTE
When the servicing or maintenance is completed and the COMPex*Pro* excimer laser device is ready to return to the normal operating condition, follow steps 12 to 15.

12. Check the laser device and the immediate area around the laser device to ensure that nonessential items have been removed and that the laser device is operationally intact.
13. Check the work area to ensure that all employees have been safely positioned or removed from the area.
14. Remove the lockout device.

NOTE
The lockout device shall be removed from the energy isolating device by the person who applied the device. If the authorized person who applied the device is not available, contact the supervisor of the person who applied the device.

15. Notify the responsible persons that the servicing or maintenance is completed and that the laser device can be switched on and restored to service.

A0510COMPPRO

7.4 Gas System Maintenance

This section describes the procedures that are to be followed to maintain the external gas system. The condition of the external gas system and the gases has a direct influence on the operating performance of the excimer laser.

NOTE
The instructions in this section apply for a straight-forward gas system with one gas source for one laser device. In industrial environments, the COMPex*Pro* may be connected to an external gas handling system that serves a number of laser devices. Therefore, always consult the gas handling system supplier's instructions before performing any of the actions described in this section.

7.4.1 Flush Gas Line

Purpose

Evacuate a gas line and fill the line with fresh gas. This is, for example, necessary to remove helium from the gas line after a leak test or after starting the laser following a week of non-use or to remove impurities in the gas line after exchanging a gas cylinder.

Maintenance Interval

- Before a new gas fill
- After a week of non-operation

Time Required

- 0.1 h

Tools and Materials

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Gases as specified (see Section 4.2.2 on page 76). Gas cylinders with a remaining pressure of at least 10 bar (abs.)

A0510COMPPRO

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.2.2 on page 76)

Evacuating the Gas Line

1. Close the corresponding gas cylinder valve.
2. Ensure that the pressure regulator in the gas line is open.
3. Press <FLUSH LINE> on the handheld keypad.
   "FLUSH: *current selection* (INERT, BUFFER, RARE, HAL.)" appears in the bottom line of the display
4. Press <Cursor Right> and/or <Cursor Left> to select the desired gas line.
5. Press <ENTER> to confirm the selection.
6. Press <EXE> to evacuate the selected gas line between the laser head valve and the gas cylinder valve.
   The message "FLUSH: *current selection* L." appears in the bottom line of the display.

   The vacuum pump runs for two seconds to evacuate the gas line.

NOTE
Depending on the length of the gas line, this procedure has to be repeated until the gas line is completely evacuated.

Filling the Gas Line with Fresh Gas

7. Open the gas cylinder valve that was closed in step 1.
8. Repeat the procedure at least once with the gas supply open (i.e. from step 2) to completely fill the line.

7.4.2 Purge Gas Line

Purpose

Evacuate the gas line for five seconds and then fill the line with the gas connected to the INERT connection (helium). This is, for example, necessary to perform a leak test with a helium leak tester or to remove impurities from the system when the laser is not used for a number of days.

A0510COMPPRO

Tools and Materials

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Gases as specified (see Section 4.2.2 on page 76). Gas cylinders with a remaining pressure of at least 10 bar (abs.)

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.2.2 on page 76)

NOTE
When the gas supply is closed, the message ”NO GAS FLOW“ appears when purging the line.

Purging the Gas Line

1. Close the pressure regulator in the gas line that is to be purged.
2. Ensure that the inert gas cylinder valve is open and the pressure regulator is set to at least 4 bar (abs.).

NOTE
The pressure regulator has to be set to at least 4 bar to completely purge the line between the gas cylinder valve and the laser head. With lower pressure settings, residues may remain in the line between the pressure regulator and the gas cylinder valve.

3. Press <PURGE LINE> on the handheld keypad.
   “PURGE: *current selection* (INERT, BUFFER, RARE, HAL.)” appears in the bottom line of the display.
4. Press <Cursor Right> and/or <Cursor Left> to select the desired gas line.
5. Press <ENTER> to confirm the selection.

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6. Press <EXE> to start the purging procedure.
   The message “PURGE: *current selection*“ appears in the bottom line of the display. “OFF” appears in the display when the line purging has been completed.

NOTE
A) Depending on the length of the gas line, this procedure has to be repeated until the gas line is completely purged.
B) Before restarting laser operation, the gas line has to be completely filled with the appropriate gas for the line (see Section 7.4.1 on page 179).

7.4.3 Exchange Halogen Gas Cylinder

Purpose

Replace exhausted or expired halogen gas cylinders with fresh gas cylinders.

NOTE
After exchanging the gas cylinder, use inert gas to check the corresponding line for leaks.

Maintenance Interval

- If pressure in the gas cylinder drops below 10 bar

NOTE
To ensure that there is adequate gas pressure for all gas activities, it is recommended that the gas cylinder be exchanged when the remaining pressure drops below 20 bar.

- When gas cylinder has passed expiry date

Time Required

- 0.75 h

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Tools and Materials

- Appropriate wrench to disconnect/re-connect gas cylinders
- Stainless steel cap (e.g. laser device's gas line blanking plug removed during the installation) for sealing the halogen line
- Helium leak tester or liquid leak tester (e.g. SNOOP®)

NOTE
Make sure that the chosen leak tester is suitable for use in the environment in which the laser is installed. Liquid leak testers are, for instance, not permitted in cleanrooms.

- Ethanol and cleaning paper (when SNOOP® was used)

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Gases as specified (see Section 4.2.2 on page 76). Gas cylinders with a remaining pressure of at least 10 bar (abs.)

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements.

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Pressure regulators and cylinder valves in each gas line closed.

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Evacuating the Halogen Line

CAUTION
Incorrect operation can damage the pressure regulator!
If pressure is applied to a pressure regulator with low secondary pressure, the pressure regulator membrane may become damaged. Always ensure that the pressure regulator is closed, before opening the gas cylinder valve.

1. Open the halogen gas cylinder valve.
2. Set the pressure regulator in the halogen line to at least 4 bar (abs.).

NOTE
The pressure regulator has to be set to at least 4 bar to completely evacuate the line between the gas cylinder valve and the laser head. With lower pressure settings, residues may remain in the line between the pressure regulator and the gas cylinder valve.

3. Close the halogen gas cylinder valve.
4. Evacuate the halogen gas line without refilling it (see Section 7.4.1 on page 179).

Purging the Halogen Gas Line

WARNING
Health hazard through halogen gases !
The halogen gas line to an excimer laser contains a mixture of up to 5% fluorine gas or 0.5% hydrogen chloride.
Always purge the halogen gas line before separating it. Avoid breathing in or skin contact with halogen gases.

5. Open the inert gas cylinder valve.
6. Set the pressure regulator in the inert line to at least 4 bar (abs.).

NOTE
The pressure regulator has to be set to at least 4 bar to completely purge the line between the gas cylinder valve and the laser head. With lower pressure settings, residues may remain in the line between the pressure regulator and the gas cylinder valve.

7. Purge the halogen gas line at least four times (see Section 7.4.2 on page 180). The halogen gas line is now free of halogen so that the gas cylinder can now be changed.

Exchanging the Halogen Gas Cylinder

8. Close the pressure regulator and gas cylinder valve.

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9. Separate the gas line from the gas cylinder.

NOTE
Depending on the manufacturers instructions, the pressure regulator may also have to be exchanged.

CAUTION
Risk of corrosion!
The halogen gas line is not to be left open for more than two minutes. Always seal the halogen line with a stainless steel cap when the line is to be separated for a longer period.

10. Seal the halogen line with a stainless steel cap to prevent corrosion.
11. Exchange the halogen gas cylinder.
12. Remove the stainless steel cap from the halogen line.

CAUTION
Risk of gas leaks!
When using gaskets to seal the gas lines, always use new (unused) gaskets..

13. Screw the line fittings to the halogen gas cylinder or alternatively to the pressure regulator if this was exchanged together with the gas cylinder.

Checking the Ga s Line for Vacuum Leak Tightness

14. Ensure that the pressure regulators and cylinder valves are closed on all gas lines.
15. Open the halogen gas cylinder valve.
16. Set the pressure regulator in the halogen line to at least 4 bar (abs.).

NOTE
The pressure regulator has to be set to at least 4 bar to completely evacuate the line between the gas cylinder valve and the laser head. With lower pressure settings, residues may remain in the line between the pressure regulator and the gas cylinder valve.

17. Close the halogen gas cylinder valve.
18. Press <FLUSH LINE> on the handheld keypad.
    “FLUSH: *current selection* (INERT, BUFFER, RARE, HAL.)” appears in the bottom line of the display
19. Press <Cursor Right> and/or <Cursor Left> to select HAL (halogen).
20. Press <ENTER> to confirm the selection.

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21. Press <EXE> to evacuate the selected gas line between the laser head valve and the gas cylinder valve.
    The message ”FLUSH: HAL.“ appears in the bottom line of the display.

    The vacuum pump runs for two seconds to evacuate the gas line.
22. Repeat step 21 until the pressure regulator gauge indicates a relatively constant vacuum.

NOTE
If a vacuum is not reached there is a relatively large leak in the gas line. Check all connections in the line. If necessary, tighten the connections and repeat the evacuation of the gas line.

23. After appoximately 10 minutes, check the pressure regualator gauge again. A significant increase in pressure indicates a leak.
24. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test.

Checking the Gas Line for Overpressure Leak Tightness

25. Open the inert gas cylinder valve.
26. Set the pressure regulator in the inert gas line to the specified value (see Section 4.2.2 on page 76).
27. Press <PURGE LINE> on the handheld keypad.
    “PURGE: *current selection* (INERT, BUFFER, RARE, HAL.)” appears in the bottom line of the display.
28. Press <Cursor Right> and/or <Cursor Left> to select HAL. (halogen).
29. Press <ENTER> to confirm the selection.
30. Press <EXE> to start the purging procedure.
    The message “PURGE: HAL.“ appears in the bottom line of the display.

    The halogen gas line and the internal gas system are evacuated and filled with inert gas (He).

NOTE
Depending on the configuration of the gas system, the command has to be repeated until the gas line is completely purged.

31. Use a leak tester to check the gas line connections for leaks .
32. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test

Cleaning, Refilling and Passivating the Gas Line

33. Close the pressure regulator in the halogen line.
34. Open the halogen gas cylinder valve.
35. Set the pressure regulator in the halogen gas line to the specified value (see Section 4.2.2 on page 76).

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36. Press <FLUSH LINE> on the handheld keypad.
    “FLUSH: *current selection* (INERT, BUFFER, RARE, HAL.)” appears in the bottom line of the display
37. Press <Cursor Right> and/or <Cursor Left> to select HAL (halogen).
38. Press <ENTER> to confirm the selection.
39. Press <EXE> a number of times to clean the halogen gas line. The halogen line is evacuated and at the same time refilled with fresh gas.
40. Leave the halogen gas in the gas line for approx. 15 minutes.
41. After waiting approx. 15 minutes, press <EXE> again to fill the halogen line with fresh gas.

NOTE
Depending on the configuration of the gas system, the command has to be repeated until the gas line is completely filled.

Finalization

42. When SNOOP® was used, clean the gas line connections with ethanol and wipe dry with cleaning paper.
43. Set the gas cylinder valves and pressure regulators to the settings required for the next laser operation (closed for NGR, open and correctly set for PGR).

7.4.4 Exchange Rare, Buffer or Inert Gas Cylinder

Purpose

Replace exhausted or expired rare, buffer or inert gas cylinders with fresh gas cylinders.

NOTE
After exchanging the gas cylinder, use inert gas to check the line for leaks instead of expensive rare or buffer gases .

Maintenance Interval

- If pressure in the gas cylinder drops below 10 bar

NOTE
To ensure that there is adequate gas pressure for all gas activities, it is recommended that the gas cylinder be exchanged when the remaining pressure drops below 20 bar.

- When gas cylinder has passed expiry date

Time Required

- 0.5 h

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Tools and Materials

- Appropriate wrench to disconnect/reconnect gas cylinders
- Stainless steel cap (e.g. laser device's gas line blanking plug removed during the installation) for sealing the halogen line
- Helium leak tester or liquid leak tester (e.g. SNOOP®)

NOTE
Make sure that the chosen leak tester is suitable for use in the environment in which the laser is installed. Liquid leak testers are, for instance, not permitted in cleanrooms.

- Ethanol and cleaning paper (when SNOOP® was used)

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Gases as specified (see Section 4.2.2 on page 76). Gas cylinders with a remaining pressure of at least 10 bar (abs.)

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Pressure regulators and cylinder valves in each gas line closed.

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Evacuating the Gas Line

CAUTION
Incorrect operation can damage the pressure regulator!
If pressure is applied to a pressure regulator with low secondary pressure, the pressure regulator membrane may become damaged. Always ensure that the pressure regulator is closed, before opening the gas cylinder valve.

1. Open the corresponding gas cylinder valve.
2. Set the pressure regulator in the corresponding gas line to at least 4 bar (abs.).

NOTE
The pressure regulator has to be set to at least 4 bar to completely evacuate the line between the gas cylinder valve and the laser head. With lower pressure settings, residues may remain in the line between the pressure regulator and the gas cylinder valve.

3. Close the corresponding gas cylinder valve.
4. Evacuate the corresponding gas line without refilling it (see Section 7.4.1 on page 179).

Exchanging the Gas Cylinder

5. Close all pressure regulators and gas cylinder valves.
6. Separate the gas line from the gas cylinder.

NOTE
Depending on the manufacturers instructions, the pressure regulator may also have to be exchanged.

7. Exchange the gas cylinder.

CAUTION
Risk of gas leaks!
When using gaskets to seal the gas lines, always use new (unused) gaskets.

8. Screw the line fittings to the corresponding gas cylinder or alternatively to the pressure regulator if this was exchanged together with the gas cylinder.

Checking the Gas Line for Vacuum Leak Tightness

9. Ensure that the pressure regualtors and cylinder valves are closed on all gas lines.
10. Open the corresponding gas cylinder valve.

A0510COMPPRO

11. Set the pressure regulator in the corresponding line to at least 4 bar (abs.).

NOTE
The pressure regulator has to be set to at least 4 bar to completely evacuate the line between the gas cylinder valve and the laser head. With lower pressure settings, residues may remain in the line between the pressure regulator and the gas cylinder valve.

12. Close the corresponding gas cylinder valve.
13. Press <FLUSH LINE> on the handheld keypad.
    “FLUSH: *curre nt selection* (INERT, BUFFER, RARE, HAL.)” appears in the bottom line of the display
14. Press <Cursor Right> and/or <Cursor Left> to select the desired gas line.
15. Press <ENTER> to confirm the selection.
16. Press <EXE> to evacuate the selected gas line between the laser head valve and the gas cylinder valve.
    The message ”FLUSH: *current selection*“ appears in the bottom line of the display.

    The vacuum pump runs for two seconds to evacuate the gas line.
17. Repeat step 16 until the pressure regulator gauge indicates a relatively constant vacuum.

NOTE
If a vacuum is not reached there is a relatively large leak in the gas line. Check all connections in the line. If necessary, tighten the connections and repeat the evacuation of the gas line.

18. After appoximately 10 minutes, check the pressure regualator gauge again. A significant increase in pressure indicates a leak.
19. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test.

Checking the Gas Line for Overpressure Leak Tightness

20. Open the inert gas cylinder valve.
21. Set the pressure regulator in the inert gas line to the specified value (see Section 4.2.2 on page 76).
22. Press <PURGE LINE> on the handheld keypad.
    “PURGE: *current selection* (INERT, BUFFER, RARE, HAL.)” appears in the bottom line of the display.
23. Press <Cursor Right> and/or <Cursor Left> to select the desired gas line.
24. Press <ENTER> to confirm the selection.

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25. Press <EXE> to start the purging procedure.
    The message “PURGE: *current selection*“ appears in the bottom line of the display. The corresponding gas line and the internal gas system are evacuated and filled with inert gas (He).

NOTE
Depending on the configuration of the gas system, the command has to be repeated until the gas line is completely purged.

26. Use a leak tester to check the gas line connections for leaks .
27. If there is a leak, tighten the connections and, where necessary, exchange the sealing ring. Following this, repeat the leak test

Cleaning, Refilling and Passivating the Gas Line

28. Close the pressure regulator in the corresponding line.
29. Open the corresponding gas cylinder valve.
30. Set the pressure regulator in the corresponding gas line to the specified value (see Section 4.2.2 on page 76).
31. Press <FLUSH LINE> on the handheld keypad.
    “FLUSH: *current selection* (INERT, BUFFER, RARE, HAL.)” appears in the bottom line of the display
32. Press <Cursor Right> and/or <Cursor Left> to select the desired gas line.
33. Press <ENTER> to confirm the selection.
34. Press <EXE> a number of times to clean the gas line.
    The corresponding line is evacuated and at the same time refilled with fresh gas.

NOTE
Depending on the configuration of the gas system, the command has to be repeated until the gas line is completely filled.

Finalization

35. When SNOOP® was used, clean the gas line connections with ethanol and wipe dry with cleaning paper.
36. Set the gas cylinder valves and pressure regulators to the settings required for the next laser operation (closed for NGR, open and correctly set for PGR).

A0510COMPPRO

7.5 Laser Tube Maintenance

7.5.1 New Fill

Purpose

Evacuate spent excimer laser gases from the laser tube and fill the laser tube with the appropriate fresh excimer laser gases. The laser tube is automatically evacuated and filled to the required pressure through the dedicated software routine “NEW FILL”. The exact gas mixture is determined through the currently active gas menu.

The gas lifetime is largely dependent on the operating conditions. The frequency with new fills are required should be recorded so that you can prepare a maintenance schedule specific to your individual requirements. Note the date and total counter reading at which each new fill is made in your laser logbook.

The following situations will reduce the laser gas lifetime:

– the laser tube has just been passivated,

– the first fill after a period of weeks without laser operation,

– a different wavelength has been selected,

– the laser tube optics are contaminated,

– high energy values in the EGY CONST mode.

Maintenance Interval

- ArF, KrF, XeF and XeCl Versions
  - Every 5 to 25 million pulses
  - Every 1 to 2 weeks
- F_2 Version
  - Every 1 to 5 million pulses
  - Every 3 to 5 days

A new gas fill is also recommended:

- If beam output energy is too low for your application
- After a warning or error message ”PRESET ENERGY TOO HIGH“, “NEW GAS FILL NEEDED“ or “LOW LIGHT“
- Before calibrating the energy monitor
- After re-passivating the laser tube

Time Required

- 0.5 h

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Tools and Materials

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Gases as specified (see Section 4.2.2 on page 76). Gas cylinders with a remaining pressure of at least 10 bar (abs.)

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.2.2 on page 76)
- No impurities in the laser tube or gas lines

NOTE
When the laser has not been run for more than a month, flush the gas lines to remove any impurities (see Section 7.4.1 on page 179).

Evacuating and Filling the Laser Tube

1. Turn on the excimer laser gases and set the pressure regulator in each line to the required pressure (see Section 6.2.2 on page 150).
2. Press <NEW FILL> on the handheld keypad.
   "> NEW FILL" appears in the bottom line of the display.
3. Press <ENTER> to confirm that a new fill is to be started.

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4. Press <EXE> to start the NEW FILL procedure.

NOTE
Only interrupt the procedure with <BREAK> in case of an emergency. As the procedure is immediately interrupted and the fill is incomplete, there may be insufficient pressure in the laser tube. In this case, manually fill the laser tube to 1050 mbar with inert gas (see Section 6.4.9 on page 171) or restart the new fill procedure.

At the start of the new fill, the halogen filter ratio is checked. If it exceeds 99 %, the message „RENEW HALOGEN FILTER“ is displayed and the NEW FILL procedure terminates. Replace the halogen filter.

The vacuum pump starts to evacuate the tube, the current pressure and the message “NEW FILL, EVAC“ are displayed. After reaching 30 mbar the vacuum pump stops. The laser then enters a two minute stand-by phase for a laser tube gas leak check. The message “NEW FILL, WAIT“ is displayed. If everything is all right, the message changes to “NEW FILL, FILL“. The individual gases are then filled into the laser tube at the partial pressures indicated in the gas menu. “OFF” appears in the display when the new fill has been completed.

CAUTION
Penetration of atmospheric oxygen can damage the laser tube! Evacuation of the laser tube was most likely inhibited by a leak. Each attempt to evacuate a leaking laser tube allows atmospheric oxygen to penetrate the laser tube. Always locate and rectify a leak before continuing the new fill.

If the evacuation fails, the message “SAFETY FILL“ appears and a safety fill is performed. This automatically fills the laser tube to 1050 mbar with the gas connected to the buffer gas connection.

A0510COMPPRO

7.5.2 Manual Halogen Injection

Purpose

CAUTION
Risk of damaging the laser tube!
Contamination can collect in the tube and can cause damage to the tube or parts of the tube.
Never perform more than three manual halogen injections before performing a partial gas replacement.

Manually inject halogen gas into the laser tube to, for instance, compensate for a drop in output power. The amount of gas injected is determined in the gas menu.

NOTE
A) This function can only be performed when the laser is supplied from separate gas cylinders.
B) If there is no improvement in laser performance after the manual halogen injection, always carry out a new fill (see Section 7.5.1).

Tools and Materials

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Halogen gas as specified (see Section 4.2.2 on page 76). Gas cylinder with a remaining pressure of at least 10 bar (abs.)

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Halogen gas cylinder valve open and pressure regulator correspondingly set (for secondary pressure see Section 4.2.2 on page 76)

A0510COMPPRO

Injecting Halogen Gas

1. Press <F7> on the handheld keypad.
2. Press <ENTER> to confirm that a halogen injection is to be started.
3. Press <EXE> to start the halogen injection.

   The laser head valve and halogen valve open for two seconds and then automatically close again.

7.5.3 Purge Laser Tube

Purpose

Replace the laser gas in the laser tube with inert gas. The “purge reservoir” procedure evacuates the laser tube and fills it to 1050 mbar with the gas that is connected to the inert gas line.

NOTE
The <PURGE RESERVOIR> key calls two different procedures: reservoir purging and window exchange. The window exchange procedure is described in Section 7.6.1 on page 201.

Maintenance Interval

Purging the laser tube is recommended:

- When the laser was not in use for more than one month
- After repairing a leak in the laser tube.

Tools and Materials

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Inert gas as specified (see Section 4.2.2 on page 76). Gas cylinder with a remaining pressure of at least 10 bar (abs.)

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Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Inert gas cylinder valve open and pressure regulator correspondingly set (for secondary pressure see Section 4.2.2 on page 76)

Purging the Tube with Inert Gas

1. Close all pressure regulators and gas cylinder valves.
2. Open the valve on the inert gas cylinder.
3. Set the pressure regulator in the inert gas line to the required pressure.
   The gas pressures are indicated in Section 4.2.2. on page 76.
4. Press <PURGE RESERVOIR>.
5. Where necessary, press cursor left or cursor right to select “PURGE RES”.
6. Press <ENTER> to confirm the choice.
7. Press <EXE> to proceed. The message ”FLUSHING...“ appears.

   The vacuum pump starts to evacuate the laser tube. After reaching 30 mbar, the vacuum pump stops, inert gas valve opens and the tube is filled to 1050 mbar with inert gas.

NOTE
Only interrupt the procedure with <BREAK> in case of an emergency. As the procedure is immediately interrupted and the fill is incomplete, there may be insufficient pressure in the laser tube. In this case, manually fill the laser tube to 1050 mbar with inert gas (see Section 6.4.9 on page 171) or restart the purging procedure.

Finalization

8. Carry out a new fill before restarting laser operation (see Section 7.5.1).

A0510COMPPRO

7.5.4 Re-Passivate Laser Tube

Purpose

Re-passivate the laser tube after a long period without laser operation or when the passivation of the tube has become damaged through contact with the ambient air.

Halogen gases are aggressive substances. To protect the tube and other components, these are designed so that a protective passivation layer is formed when the material comes into contact with a halogen gas.

NOTE
This function can only be performed when the laser is supplied from separate gas cylinders.

CAUTION
Risk of damaging the laser tube!
Do not use this re-passivation procedure when changing the type of gas in a multigas tube (e.g. fluorine to hydrogen chloride or vice-versa). In this case, contact the Lambda Physik Service Center.

Time Required

- 24 hours (recommendation)

Tools and Materials

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Gases as specified (see Section 4.2.2 on page 76). Gas cylinders with a remaining pressure of at least 10 bar (abs.)

A0510COMPPRO

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Gas cylinder valves open and pressure regulators closed

Passivating the Laser Tube

1. Open the valve on the halogen gas cylinder.
2. Set the pressure regulator in the halogen gas line to the required pressure.
   The gas pressures are indicated in Section 4.2.2. on page 76.
3. Open the valve on the helium gas cylinder.
4. Set the pressure regulator in the helium gas line to the required pressure.
   The gas pressures are indicated in Section 4.2.2. on page 76.
5. Press <F3>.
6. Press <EXE> to confirm the choice and start the re-passivation procedure.

   The tube is evacuated to 30 mbar and filled with 200 mbar halogen gas and 900 mbar helium.
7. Leave the laser with the passivation fill for at least 8 hours (e.g. overnight) to allow the halogen to displace the oxygen compounds from the surfaces with which it comes into contact.

Finalization

8. Carry out a new fill (see Section 7.5.1).

   The displaced oxygen compounds are removed during evacuation of the tube before the fresh gas is filled.

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7.6 Tube Optics Maintenance

Maintenance of the laser optics consists of cleaning and exchange.

Cleaning the optics is necessary

– after a specific number of pulses (dependent on gas mixture / wavelength),

– if the pulse energy is too low,

– if the beam profile is poor.

Exchange of the optics is necessary

– if the optics are damaged (e.g. scratched),

– if the optics are unable to be cleaned (e.g. burned-in deposits),

– after a specific number of optics cleaning operations (dependent on gas mixture / wavelength).

Each of the optics is contained in a dedicated optics mount that first has to be removed from the laser device and disassembled before the optic can be cleaned or exchanged.

NOTE
To maximize uptime, sets of ready-to-use laser optics can be prepared and stored in spare mounts. This enables contaminated or damaged laser optics to be maintained at your convenience while the laser is running.

Maintenance of the tube optics differs depending on the version of the COMPex*Pro* laser device:

– The procedures for the COMPex*Pro* 100 and COMPex*Pro* 200 is described in Sections 7.6.1, 7.6.2 (page 208) and 7.6.3 (page 211).

– The procedure for the COMPex*Pro* F_2 is described in Sections 7.6.4 (page 214) and 7.6.5 (page 221).

NOTE
The optics of the COMPex*Pro* F_2 are not intended to be cleaned, i.e. the optics are only to be exchanged.

A0510COMPPRO

7.6.1 Exchange Pre-Mounted Tube Optics (COMPex*Pro* 100 / COMPex*Pro* 200)

Purpose

Remove the optics mounts containing contaminated damaged or worn optics (output coupler and rear mirror) from the laser device and insert new or clean premounted optics into the laser device.

Prior to removing the optics mounts, the gas mixture has to be pumped out of the laser tube and the tube refilled with the gas connected to the inert valve. Following replacement of the optics, a leak test has to be performed. These procedures are controlled through a dedicated software routine.

NOTE
Always change the output coupler and the rear mirror in two seperate procedures to ensure that one of the optics is remains adjusted. The replaced optics can then be aligned with the optics that are still adjusted. When the tube optics is replaced in one single procedure, resonator adjustment can only be performed by specially trained personnel or authorized service.

Maintenance Interval

- Remove optics for cleaning:
  - Every 10 to 30 million pulses
  - Every 3 to 5 new gas fills
- Exchange optics:
  - After cleaning the tube windows five times
  - If the optics are damaged or unable to be cleaned

NOTE
With ArF versions, always exchange the optics after cleaning every third time.

Time Required

- 1.0 h

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Tools and Materials

- 4 mm allen key (from service case)
- 3 mm allen key (from service case)
- 2.5 mm allen key (from service case)
- Sealing plate or premounted optics mounts
- External energy meter (for handling, see energy meter manual)
- Gases as specified (see Section 4.2.2 on page 76). Gas cylinders with a remaining pressure of at least 10 bar (abs.)

CAUTION
Risk of damaging optical components through contamination!
Contamination can cause serious damage to the optical components.
Always wear disposible plastic gloves when working with and on optical components.

- Disposable skin-tight plastic gloves

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.2.2 on page 76)

Flushing the Laser Tube

1. Ensure that the cylinder valve and pressure regulator in the inert gas line are closed.
2. Open the valve on the inert gas cylinder.
3. Set thepressure regulator in the inert gas line to the specified value (see Section 4.2.2 on page 76).
4. Press <PURGE RESERVOIR>.
   A list of selections appears in the bottom line of the display.
5. Press <Cursor Right> and/or <Cursor Left>to select ”WIN.EXCHANGE“ .
6. Press <ENTER> to confirm.

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7. Press <EXE> to fill the laser tube with inert gas.

   The vacuum pump starts to evacuate the laser tube. After reaching 30 mbar, the vacuum pump stops, the inert gas valve opens and the laser tube is filled to 1200 mbar with inert gas. The inert gas valve then closes.

   After filling the laser tube, “REPLACE WINDOWS (enter)” appears to indicate the the windows can now be exchanged.

CAUTION
Risk of damaging laser tube.
Do not press <ENTER> when the tube windows are removed as this would cause a large amount of ambient air to enter the laser tube.

Removing the Output Coupler

8. Use the 3 mm allen key to remove the front and rear mirror access covers from the laser device.

NOTE
Removal of the mirror access covers (shutter panels) provides sufficient access to enable removal of the front optics. If access is nevertheless restricted, remove the service panel to gain access to the optics.

9. Use the 4 mm allen key to remove the screw (see Figure 72, A) that secures the energy monitor (B).

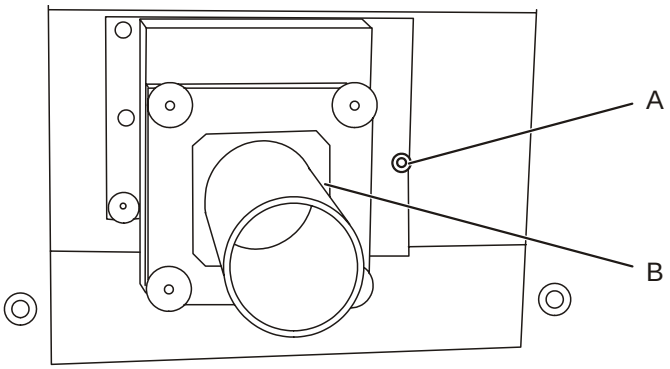

Figure 72: *Removing the energy monitor*

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10. Turn aside the energy monitor.
    The front optics are now accessible (see Figure 73).

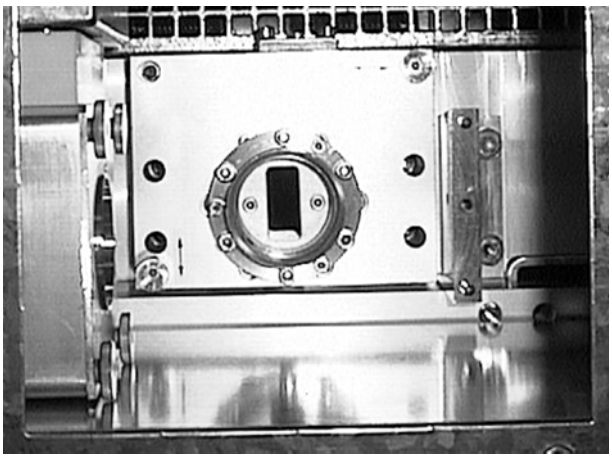

Figure 73: *View of the optics mount with energy monitor removed*

CAUTION
Risk of damaging optical components!
There is overpressure in the laser tube. Always hold the optic mount with the other hand while loosening it. Loosen the screws crosswise and in stages. Always wear disposable plastic gloves when handling optical components.

11. Use the 3 mm allen key to loosen the six screws securing the optics mount and then remove the optics mount.
    You will hear a short hissing sound due to the overpressure in the tube. The laser tube is now open.

    The inert gas valve opens every two seconds to compensate for the pressure drop and prevent air from entering the tube.

    When the laser tube is open for longer than one minute, the message ”CLOSE RESERVOIR (enter)“ appears indicating that the sealing plate or replacement optics mount should be inserted.

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CAUTION
Risk of damaging laser tube.
The software routine is automatically continued by pressing <ENTER>. Do not press <ENTER> when the tube windows are removed.

12. Immediately insert the sealing plate (see Figure 74) or a ready prepared optics mount (see Figure 75). Tighten the six screws securing the optics mount crosswise and stages with the 3 mm allen key.

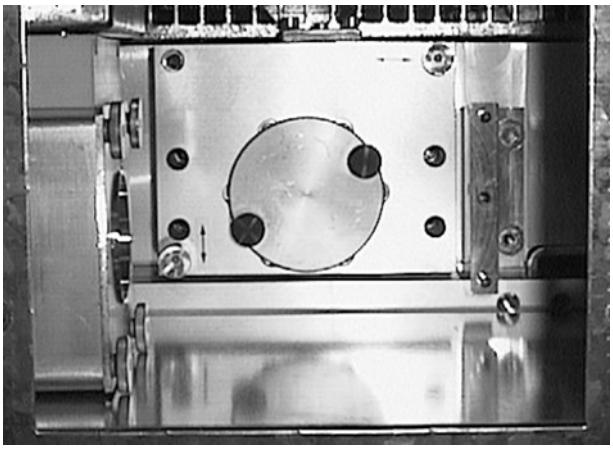

Figure 74: *Sealing plate installed in stead of optics mount*

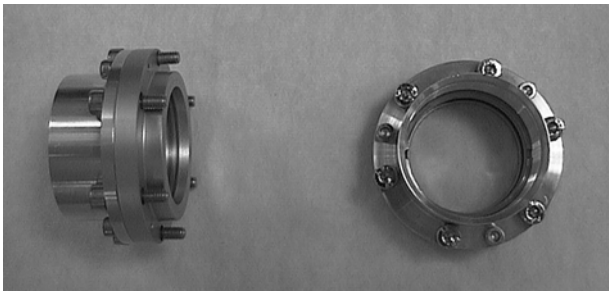

Figure 75: *Optics mount*

Preparing the Removed Optics for Re-Installation

13. Disassemble the optics mount and clean or replace the optics (see Section 7.6.2 on page 208).

NOTE
If a ready prepared optic was installed in step 12, the contaminated or worn optic can be cleaned or exchanged after the laser has been put back into operation.

14. If necessary, remove the sealing plate and insert the optics mount as described in step 12.

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Leak Testing the Laser Tube

15. Press <ENTER> to confirm that the optics have been exchanged.

    An automatic leak test is started. The laser is filled to 3000 mbar with inert gas and the cavity pressure is monitored over a 15 minute period. During this time the message “LEAK TEST“ is displayed. Should a leak be detected, the laser tube is evacuated to approx. 1200 mbar and the warning message “Leak!-Check Windows“ appears. Locate the exact source of the leak and rectify.

16. When no leak is detected, press <ENTER> to proceed.

    The laser tube is then evacuated to 30 mbar and filled to 500 mbar twice before being evacuated and finally filled to 1050 mbar.

Refilling the Laser Tube

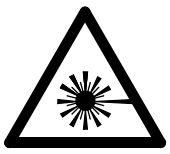
17. Perform a new fill (see Section 7.5.1 on page 192) to fill fresh excimer laser gas into the laser tube.

NOTE
We recommend running rhe laser for a few minutes to warm up the excimer laser gas mixture before continuing with the next stage of the procedure.

Adjusting the Output Coupler

NOTE
Always adjust the newly installed optic before exchanging the other optic .

18. Place an external energy measuring device in the beam path (please refer to the energy measuring device’s operating instructions for further information).
19. Set the the laser to the HV CONST mode, the maximum high voltage indicated on the data sheet and the repetition rate specified on the data sheet for the required beam energy (see Section 6.3 on page 160).



WARNING
Risk of serious eye injury through laser radiation!
When working with an open laser beam always familiarize yourself with the necessary safety precautions before starting the laser.
Always wear suitable eye protection. Never stare into the laser beam or its reflection. Aviod contact with the laser beam.

20. Start the laser (see Section 6.2.4 on page 155).

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21. Turn the horizontal optic adjustment screw (siehe Figure 76, A), from right to left (see Figure 76, A) until the beam energy is at its heighest.

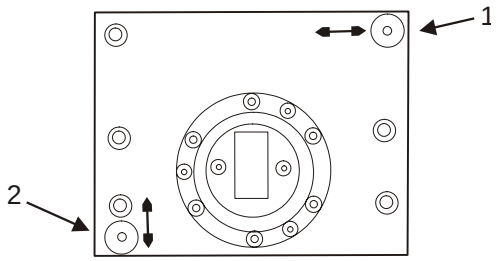

Figure 76: *Horizontal and vertical optic adjustment*

22. Repeat step 21 with the vertical optic adjustment screw (B).
23. If there is insufficient energy (see laser data sheet for the required energy output), repeat steps 21 and 22.
24. Insert the energy monitor back into the correct position in front of the output coupler and tighten using the 4 mm allen key.

Change and Adjust the Rear Mirror

25. Repeat the procedure “Flushing the Laser Tube” (see page 202) to fill the laser tube with inert gas.
26. Repeat steps 11 to 23 (from page 204) to exchange and adjust the rear mirror.

Finalization

27. Re-install the mirror access covers removed in step 8.
28. Calibrate the energy monitor (see Section 7.7.1 on page 223).

A0510COMPPRO

7.6.2 Disassemble / Assemble Tube Optics Mounts (COMPex*Pro* 100 / COMPex*Pro* 200)

Purpose

Disassemble the tube optics mounts to remove the mirrors for cleaning or exchange. Reassemble the window mounts for installation in the laser device.

Tools and Materials

- Optic mount with contaminated lens
- Optics wrench (special tool in service case)
- 2.5 mm allen key

CAUTION
Risk of damaging optical components through contamination!
Contamination can cause serious damage to the optical components. Always wear disposible plastic gloves when working with and on optical components.

- Disposable skin-tight plastic gloves

Maintenance Interval / Time Required

- See Section 7.6.1 on page 201

Preconditions

- Mirror mount with contaminated or damaged optic removed from the laser device (see Section 7.6.1 on page 201).

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Disassembling the Mirror Mount

Figure 77 shows the components of the mirror mount together with the special tool (optics wrench) required for assembly / disassembly:

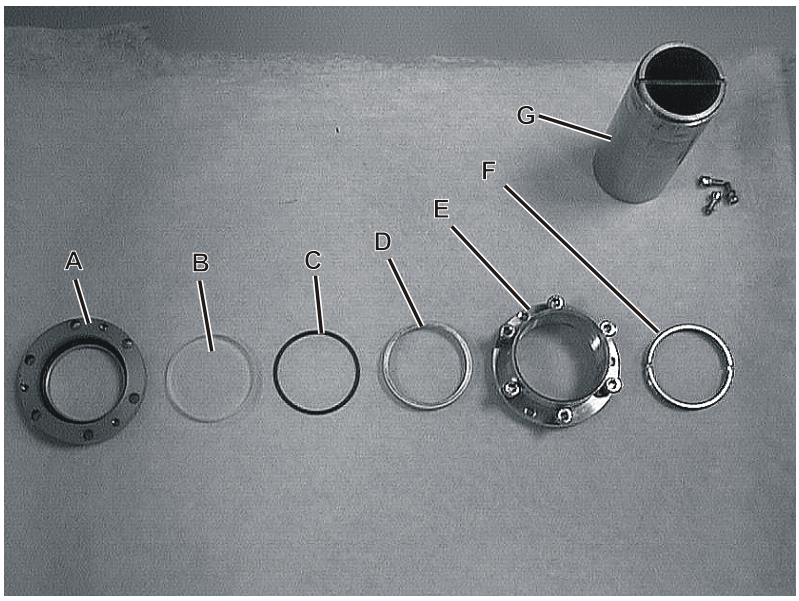

Figure 77: *Disassembled optics mount*

Key to Figure 77:

A	Counter window mount	D	Collar
B	Optic (mirror)	E	Mirror mount
C	Spacer	F	Optics wrench

CAUTION
Risk of damaging optical components through contamination!
Contamination can cause serious damage to the optical components. Always wear disposible plastic gloves when working with and on optical components.

1. Use the optics wrench to turn (approx. 5 times) and loosen the threaded inset .
2. Use the 2.5 mm allen key to loosen the three screws (do not lose the washers!) and remove window mount (E) from counter window mount (A).
3. Remove the mirror (B), and spacer (C) from the collar (D). The window is now ready for cleaning or exchange.

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Reassembling the Mirror Mount

Figure 78 shows the arrangement of the parts to reassemble the mirror mount.

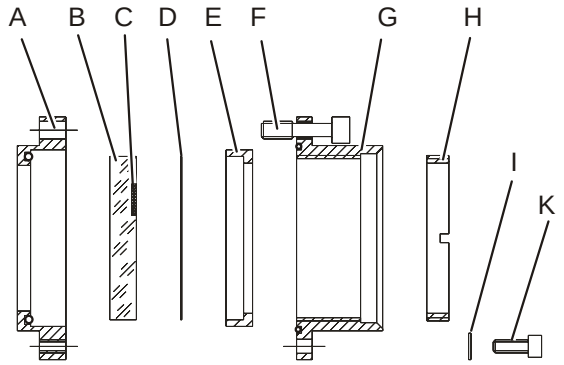

Figure 78: *Assembling the mirror mount*

Key to Figure 78:

A	Counter window mount	F	Captive screws
B	Mirror	G	Mirror mount
C	Coating mark	H	Threaded insert
D	Spacer	I	Washer
E	Collar	K	2,5 mm screw

4. Hold the coller (see Figure 78, E) and insert the spacer (D) and mirror (B) into the coller.
   The coated side of the mirror (note marking) has to point towards the spacer and collar.
5. Push the counter optic mount (A) over the collar. The non-coated side of the mirror has to point towards the counter window mount.
6. Place optic mount (G) onto the counter optic mount and use the 2.5 mm allen key to evenly tighten the three 2.5-mm screws (K).
7. Use the optics wrench to tighten the threaded insert (H) until it is finger tight.

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7.6.3 Clean Tube Optics (COMPex*Pro* 100 / COMPex*Pro* 200)

Purpose

Clean contaminated mirrors.

Tools and Materials

- Glass plate or similar clean, flat and smooth working surface
- Lens cleaning tissue
- Pressurized air or inert gas that is particulate and oil-free
- Polishing powder (e.g. vienna chalk from service case)
- Distilled water
- Optics grade Ethanol or Methanol
- Lead pencil

CAUTION
Risk of damaging optical components through contamination!
Contamination can cause serious damage to the optical components. Always wear disposible plastic gloves when working with and on optical components.

- Disposable skin-tight plastic gloves

Maintenance Interval

- Every 10 to 30 million pulses
- Every 3 to 5 new gas fills

Time Required

- 1.0 h

Preconditions

- Contaminated mirror removed from the mirror mount (see Section 7.6.2 on page 208).

A0510COMPPRO

Preparation

1. Place three layers of lens tissue on a clean, dry and smooth surface (glass plate).

CAUTION
Risk of damaging coated optics!
Use only ethanol to polish the coated side of optics. Polish carefully with gentle pressure. Wear disposable plastic gloves. Avoid touching the surface of the optic.

2. Use pressurized air or inert gas to blow off any loose particles from both sides of the optic.
3. Check that the optic has a mark indicating the coated surface.

NOTE
A) The coated side of the mirror only requires cleaning when contaminated (e.g. through fingerprints or dust).
B) The coated side of the window is usually marked with a horizontal line along the edge that has the coating or an arrow or upside down V pointing towards the coating.
C) To verify for yourself which side of the window has the coating, hold the optic at an angle while looking at reflected light from a fluorescent bulb. The reflected light will have a greenish to pink tint across the entire surface whereas the backside has no tint.

4. Use a pencil to make or enhance the mark indicating the coated surface.
5. Lay the window with the coated side downwards onto the prepared lens tissue.

Cleaning the Tube Window

NOTE
Any action performed on an optic can potentially scratch it. Always begin with the simplest cleaning approach and the one least likely to scratch the optic.

6. Place a single sheet of lens cleaning paper over the optic.
7. Put a few drops of ethanol onto the lens tissue close to one edge of the optic.
8. While holding the lens in place, drag the lens tissue across the surface of the optic.
9. Turn over the optic and repeat the above procedure to clean the coated side of the optic.
10. If the first cleaning approach did not result in a clean optic, place three fresh sheets of lens cleaning tissue onto a clean, dry and smooth surface (glass plate).
11. Mix two teaspoons of distilled water or ethanol with one teaspoon of vienna chalk on the uppermost tissue.

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12. Holding the lens between your index finger and thumb, place the uncoated side of the optic onto the vienna chalk slurry.

CAUTION
The surface of the optic is easily scratched!
Excessive downward pressure can scratch the optical surface. Let the weight of the optic apply the downward force.

13. While applying a sideways pressure, move the optic in a circular or figure-eight fashion for approx. three minutes (see Figure 79).

Figure 79: *Cleaning the uncoated side of the window*

14. Rinse the lens, e.g. under flowing distilled water.
15. Place three layers of fresh lens tissue on a clean, dry and smooth surface (glass plate).
16. Lay the window with the coated side downwards onto the prepared lens tissue.
17. Place a single sheet of lens cleaning paper over the window.
18. Put a few drops of ethanol onto the lens tissue close to one edge of the window.
19. While holding the lens in place, drag the lens tissue across the surface of the window.
20. Repeat the previous three steps until the lens is clean and dry.
21. Visually inspect the window (in a well-lit area) to ensure that it is clean and dry.
22. Put a few drops of ethanol onto the surface close to one edge.
23. Wipe a lens cleaning tissue over the surface to clean the lens with ethanol.

Finalization

24. Insert the cleaned mirror into the mirror mount (see Section 7.6.2 on page 208) ready for re-installation into the laser device.

A0510COMPPRO

7.6.4 Exchange Pre-Mounted Tube Optics (COMPex*Pro* F_2)

Purpose

Remove the optics mounts containing damaged or worn optics (output coupler and rear mirror) from the laser device and insert new pre-mounted optics into the laser device.

Prior to removing the optics mounts, the gas mixture has to be pumped out of the laser tube and the tube refilled with the gas connected to the inert valve. Following replacement of the optics, a leak test has to be performed. These procedures are controlled through a dedicated software routine.

NOTE
Always change the output coupler and the rear mirror in two seperate procedures to ensure that one of the optics remains adjusted. The replaced optics can then be aligned with the optics that are still adjusted. When the tube optics is replaced in one single procedure, resonator adjustment can only be performed by specially trained personnel or authorized service.

Maintenance Interval

- Every 10 to 30 million pulses
- Every 3 to 5 new gas fills
- If the tube optics are damaged

NOTE
The optics of the F_2 version of the COMPex*Pro* are not intended to be cleaned, i.e. the optics are only to be exchanged.

Time Required

- 1.0 h

Tools and Materials

- 4 mm allen key (from service case)
- 3 mm allen key (from service case)
- 2.5 mm allen key (from service case)
- Sealing plate or premounted optics mounts
- External energy meter (for handling, see energy meter manual)
- Gases as specified (see Section 4.2.2 on page 76). Gas cylinders with a remaining pressure of at least 10 bar (abs.)

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CAUTION
Risk of damaging optical components through contamination!
Contamination can cause serious damage to the optical components.
Always wear disposible plastic gloves when working with and on optical components.

- Disposable skin-tight plastic gloves

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.2.2 on page 76)

Flushing the Laser Tube

1. Ensure that the cylinder valve and pressure regulator in the inert gas line are closed.
2. Open the valve on the inert gas cylinder.
3. Set the pressure regulator in the inert gas line to the specified value (see Section 4.2.2 on page 76).
4. Press <PURGE RESERVOIR>.
   A list of selections appears in the bottom line of the display.
5. Press <Cursor Right> and/or <Cursor Left>to select ”WIN.EXCHANGE“ .
6. Press <ENTER> to confirm.
7. Press <EXE> to fill the laser tube with inert gas.

   The vacuum pump starts to evacuate the laser tube. After reaching 30 mbar, the vacuum pump stops, the inert gas valve opens and the laser tube is filled to 1200 mbar with inert gas. The inert gas valve then closes.

   After filling the laser tube, “REPLACE WINDOWS (enter)” appears to indicate the the windows can now be exchanged.

CAUTION
Risk of damaging laser tube.
Do not press <ENTER> when the tube windows are removed as this would cause a large amount of ambient air to enter the laser tube.

A0510COMPPRO

Removing the Output Coupler

8. Use the 3 mm allen key to remove the service panel from the laser device.
9. Disconnect the purge gas line plug and remove the purge gas line from the optics mount (see Figure 80, B).

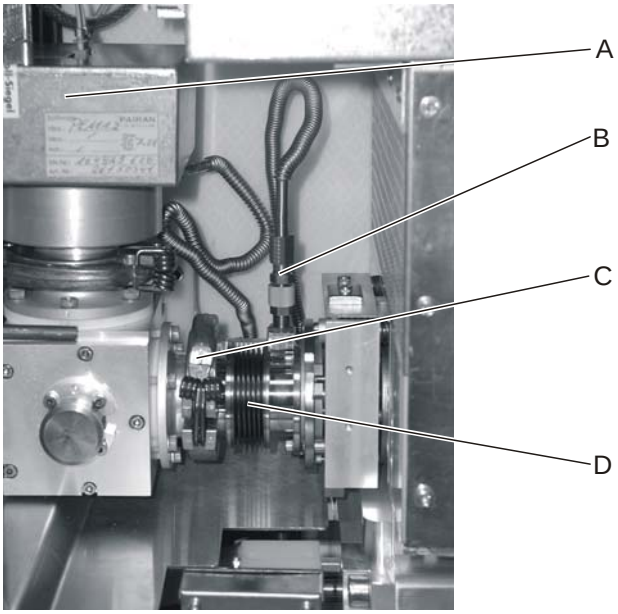

Figure 80: *Front optics with energy monitor (F_2 version)*

10. Pull the lever of the clamping ring (see Figure 80, C) that clamps the bellows onto the bending unit of the energy monitor (A) and remove the clamping ring.
11. Press the bellows (see Figure 80, D) towards the laser tube and remove the O-ring between bellows and bending unit.

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CAUTION
Risk of damaging optical components!
There is overpressure in the laser tube. Always hold the optic mount with the other hand while loosening it. Always wear disposable plastic gloves when handling optical components.

12. Insert the hook of the bayonet wrench into the lower recess of the optics mount (see Figure 81, left picture) and turn the bayonet wrench counterclockwise to loosen the optics mount.
    You will hear a short hissing sound due to overpressure in the tube. The laser tube is now open.

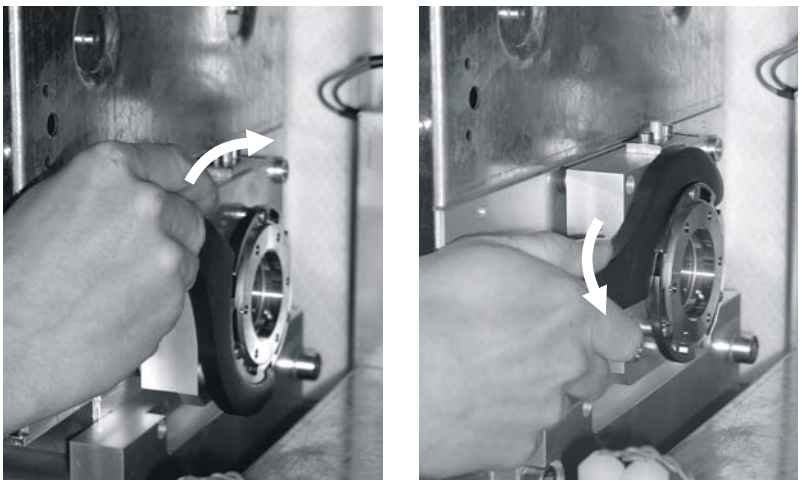

Figure 81: *Loosen and fasten front optics mount (F_2 Version)*

The inert gas valve opens every two seconds to compensate for the pressure drop and prevent air from entering the tube.

When the laser tube is open for longer than one minute, the message ”CLOSE RESERVOIR (enter)“ appears indicating that the sealing plate or replacement optics mount should be inserted.

CAUTION
Risk of damaging laser tube.
The software routine is automatically continued by pressing <ENTER>. Do not press <ENTER> when the tube windows are removed.

13. Press the bellows against the laser tube to remove the optics mount.

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14. Immediately insert the sealing plate or the ready prepared optics mount (see Figure 82) and turn the bayonet wrench clockwise to close the laser tube.

Figure 82: *Optic mount (F_2-Version)*

Preparing and Installing the Output Coupler

15. Disassemble the optics mount and replace the optics (see Section 7.6.5 on page 221).

NOTE
If a ready prepared optic was installed in step 14, the damaged or worn optic can be exchanged after the laser has been put back into operation.

16. If necessary, remove the sealing plate and insert the optics mount as described in step 14. Turn the bayonet wrench clockwise to fasten the optics mount.
17. Press the bellows (see Figure 80, D on page 216) towards the laser tube and insert the O-ring between bellows and bending unit.
18. Attach the clamping ring (see Figure 80, C) that clamps the bellows onto the bending unit of the energy monitor (see Figure 80, A) and close the lever to fix the connection.
19. Connect the purge gas line to the optics mount (see Figure 80, B).

Leak Testing the Laser Tube

20. Press <ENTER> to confirm that the optics have been exchanged.

    An automatic leak test is started. The laser is filled to 3000 mbar with inert gas and the cavity pressure is monitored over a 15 minute period. During this time the message “LEAK TEST“ is displayed. Should a leak be detected, the laser tube is evacuated to approx. 1200 mbar and the warning message “Leak!-Check Windows“ appears. Locate the exact source of the leak and rectify.
21. When no leak is detected, press <ENTER> to proceed.

    The laser tube is then evacuated to 30 mbar and filled to 500 mbar twice before being evacuated and finally filled to 1050 mbar.

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Refilling the Laser Tube

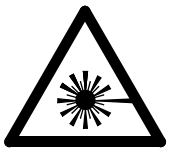
22. Perform a new fill (see Section 7.5.1 on page 192) to fill fresh excimer laser gas into the laser tube.

NOTE
We recommend running rhe laser for a few minutes to warm up the excimer laser gas mixture before continuing with the next stage of the procedure.

Adjusting the Output Coupler

NOTE
Always adjust the newly installed optic before exchanging the other optic .

23. Place an external energy measuring device in the beam path (please refer to the energy measuring device's operating instructions for further information).
24. Set the the laser to the HV CONST mode, the maximum high voltage indicated on the data sheet and the repetition rate specified on the data sheet for the required beam energy (see Section 6.3 on page 160).



WARNING
Risk of serious eye injury through laser radiation!
When working with an open laser beam always familiarize yourself with the necessary safety precautions before starting the laser.
Always wear suitable eye protection. Never stare into the laser beam or its reflection. Aviod contact with the laser beam.

25. Start the laser (see Section 6.2.4 on page 155).
26. Turn the horizontal optic adjustment screw (siehe Figure 76, A), from right to left (see Figure 76, A) until the beam energy is at its heighest.

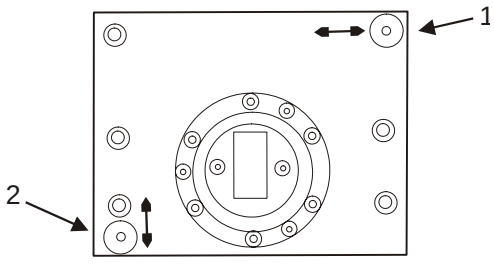


Figure 83: *Horizontal and vertical optic adjustment (F_2 version)*

27. Repeat step 21 with the vertical optic adjustment screw (B).
28. If there is insufficient energy (see laser data sheet for the required energy output), repeat steps 21 and 22.

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Removing the Rear Mirror

29. Repeat the procedure “Flushing the Laser Tube” (see page 215) to fill the laser tube with inert gas.
30. Insert the hook of the bayonet wrench into one of the recesses of the optics mountand turn the bayonet wrench counterclockwise to loosen the optics mount (see Figure 84, left picture).

    You will hear a short hissing sound due to overpressure in the tube. The inert gas valve opens every two seconds to compensate for the pressure drop and prevent air from entering the tube.

    When the laser tube is open for longer than one minute, the message ”CLOSE RESERVOIR (enter)“ appears indicating that the sealing plate or replacement optics mount should be inserted.

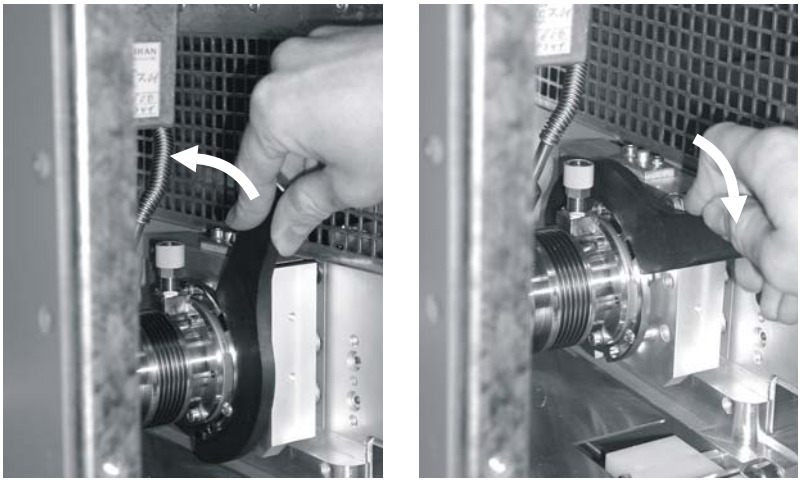

Figure 84: *Position of rear optics mount (F_2 version)*

CAUTION
Risk of damaging laser tube.
The software routine is automatically continued by pressing <ENTER>. Do not press <ENTER> when the tube windows are removed.

31. Immediately insert the sealing mount or replacement rear mirror mount and turn the bayonet wrench clockwise to close the laser tube.

Preparing and Installing the Rear Mirror

32. Disassemble the optics mount and replace the optics (see Section 7.6.5 on page 221).

NOTE
If a ready prepared optic was installed in step 31, the damaged or worn optic can be exchanged after the laser has been put back into operation.

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33. If necessary, remove the sealing plate and insert the optics mount as described in step 31. Turn the bayonet wrench clockwise to fasten the optics mount.

Leak Testing and Adjusting the Rear Mirror

34. Repeat the steps 20 to 28 (from page 218) to perform a leak test and adjust the rear mirror.

Finalization

35. Re-install the service panel removed in step 8.
36. Calibrate the energy monitor (see Section 7.7.1 on page 223).

7.6.5 Disassemble / Assemble Tube Optics Mounts (COMPex*Pro* F_2)

Purpose

Disassemble the tube optics mounts to remove the mirrors for cleaning or exchange. Reassemble the window mounts for installation in the laser device.

Tools and Materials

- Optic mount with contaminated lens
- Optics wrench (special tool in service case)
- 2.5 mm allen key

CAUTION
Risk of damaging optical components through contamination!
Contamination can cause serious damage to the optical components. Always wear disposible plastic gloves when working with and on optical components.

- Disposable skin-tight plastic gloves

Maintenance Interval / Time Required

- See Section 7.6.4 on page 214

Preconditions

- Mirror mount with contaminated or damaged optic removed from the laser device (see Section 7.6.1 on page 201).

A0510COMPPRO

Disassembling the Mirror Mount

CAUTION
Risk of damaging optical components through contamination!
Contamination can cause serious damage to the optical components. Always wear disposible plastic gloves when working with and on optical components.

1. Use the optics wrench to loosen the threaded inset (see Figure 85, A).

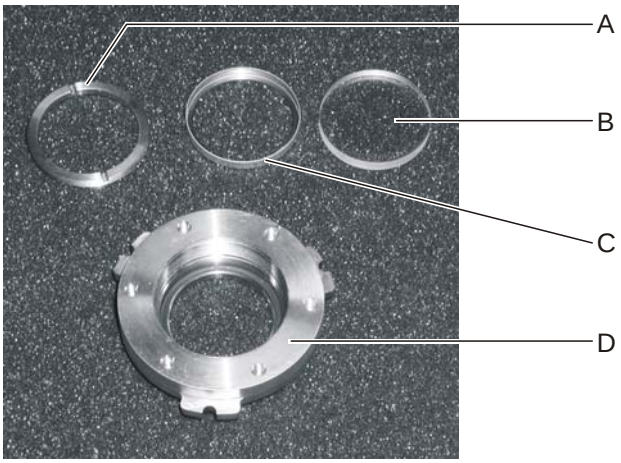

Figure 85: *Disassembled optics mount (F_2 version)*

Key to Figure 85:

A	Threaded insert	C	Optics collar
B	Mirror	D	Mirror mount

2. Remove the optics collar (C) from the mirror mount (D). Ensure that the O-ring between optics collar and mirror mount remains in its place in the mirror mount.
3. Remove the mirror (B) from the optics collar. Ensure that the red optics spacer remains in its place in the optics collar.

Reassembling the Mirror Mounts

4. Ensure that the red optics spacer is in its place in the optics collar and insert the mirror (see Figure 85, B) into the optics collar (C) with the coating facing the spacer.
5. Insert the optics collar into the mirror mount.
6. Use the optics wrench to hand-tighten the threaded inset to fix the optics collar in the mirror mount.

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7.7 Energy Monitor Maintenance

Energy monitor maintenance fundamentally consists of cleaning or exchanging the beam splitter and exchanging the energy monitor. In certain cases, attenuators may also have to be removed or inserted. As the procedure differs depending on the version of the COMPex*Pro*, this section is subdivided into the following subsections:

– Section 7.7.1 describes the energy monitor calibration procedure. The appropriate steps in this section indicate when the beam splitter is to be cleaned or exchanged and when attenuators are to be removed or inserted.

– Section 7.7.2 (page 226) describes the removal, cleaning and installation of the beam splitter. This procedure is version dependent.

– Section 7.7.3 (page 230) describes the insertion and removal of attenuators.

7.7.1 Calibrate Energy Monitor

Purpose

Calibrate the internal energy monitor in accordance with an external power or energy meter. This is performed with the help of a dedicated software option which starts the laser and enables input of a reference power value.

Maintenance Interval

- Whenever the tube windows have been cleaned / exchanged

Time Required

- 0.75 h

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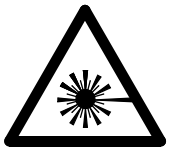
Tools and Materials

- 3 mm Allen key
- 4 mm Allen key



WARNING
Risk of injury through laser radiation!
This procedure requires working with an open laser. When laser operation is started, laser radiation will be emitted from the beam output aperture. Always wear protective eyewear and strictly adhere to the safety precautions detailed in Section 3.2.2.

- Protective eyeware suitable for the currently active laser wavelength
- Attenuators (if necessary)

CAUTION
Risk of damaging optical components through contamination!
Contamination can cause serious damage to the optical components. Always wear disposible plastic gloves when working with and on optical components.

- Disposable skin-tight plastic gloves
- Polishing powder (e.g. vienna chalk from service case)
- Lens cleaning tissues
- Distilled water
- Optics grade Ethanol or Methanol
- Pencil and paper
- Suitable energy meter or power meter (see Site Preparation for more information)

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Gases as specified (see Section 4.2.2 on page 76). Gas cylinders with a remaining pressure of at least 10 bar (abs.)

A0510COMPPRO

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Gas cylinder valves open and pressure regulators correspondingly set (for secondary pressures see Section 4.2.2 on page 76)

Preparation

1. Perform a New Fill to ensure optimum calibration conditions (see Section 7.5.1 on page 192). This takes about 20 minutes.

NOTE
Do not press <BREAK> during the new fill procedure, because the procedure is terminated immediately. The fill is not completed and the tube pressure may thus be insufficient. If this is the case start the new fill again.

2. Exchange or clean the beam splitter (see Section 7.7.2 on page 226) as indicated in the maintenance schedule.

Calibrating the Energy Monitor

3. Place and prepare the external energy meter according to the energy meter manual.
4. Switch on the laser device.
5. Press <REPRATE>.
6. Set the repetition rate so that it is suitable for the energy or power meter that you are using and press <ENTER> to confirm input.

NOTE
To obtain the best results, set the repetition rate to the rate that you normally work with.

7. Press <HV>.
8. Set the high voltage to the highest level possible for the selected repetition rate and press <ENTER> to confirm input.
9. Open the beam shutter.
10. Press <EGY CAL>.
11. Press <EXE> to confirm that the procedure is to be started.

    “WAIT...“ is displayed in the second line for a short period. The laser starts firing with the choosen repetition rate and HV.

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12. Observe the displayed values. They must be within a range of 99-200 (9.9-20 for the F_2 version).

    The laser now tries to adjust the energy monitor gain so that the (AD converter) reading is within the required range. If the reading is out of range, take note of whether it is too high or too low.

    Should none of the gain settings provide an acceptable reading, the number of attentuators has to be varied. Call COHERENT LAMBDA PHYSIK service.

    When the adjustment has succeeded, the display changes to “READING=“.

NOTE
Input values must be in mJ (1/1000 Joule). If you are using an external power meter, obtain the input value with the following equation:

$$E_{input} = \frac{P_{ext}}{1000 \cdot f}$$

where E_{input} is the input value [E_{input}] = mJ, P_{ext} is the reading from the external power meter [P_{ext}] = W and f is the repetition rate [f] = Hz.

13. Enter the external energy measurement data in mJ.
14. Press <ENTER> to confirm input.

    The laser device sets the external energy measuring data equal to the internally calculated value. The energy monitor is now calibrated.

Checking the Calibration

15. Start the laser with the currently active settings.
16. Measure a few laser pulses with the external energy meter and compare these values with those displayed by the energy monitor. They should differ no more than 2 to 3 %. If there is a larger deviation, repeat the calibration procedure from step 4.

7.7.2 Clean Beam Splitter

Purpose

Clean the beam splitter. This procedure differs for the F_2 version (see Section 7.7.2.2 on page 228). The procedure for the other versions is described in Section 7.7.2.1.

NOTE
This procedure is performed during the energy monitor calibration procedure. Consequently there are no separate lists of maintenance intervals, preconditions, or tools and materials.

A0510COMPPRO

7.7.2.1 Cleaning the Beam Splitter (COMPex*Pro* 100 / COMPex*Pro* 200)

Preparation

1. Switch off the laser device.

WARNING
Unintentional restarting can cause injury or damage!
Always secure the laser device against unintentional restarting when it is completely shut down for maintenance or repair. Before starting work, ensure that the secured by locking out the main switch. Attach appropriate safety tags.

2. Secure the laser device against unintentional restarting (see Section 7.3 on page 176).
3. Use the 3 mm allen key to remove the service panel.
4. Use the 3 mm allen key to remove the front mirror access cover from the laser device.

Removing the Beam Splitter

5. Use the 4 mm allen key to remove the screw (see Figure 72, A on page 203) that secures the energy monitor and remove the (magnetic) beam shielding.

CAUTION
Risk of damaging optical components through contamination!
Contamination can cause serious damage to the optical components. Always wear disposible plastic gloves when working with and on optical components.

6. Hold the beam splitter by the beam splitter handle (see Figure 86 D).

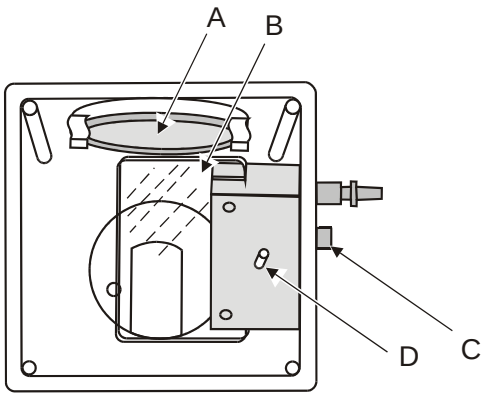

Figure 86: *View onto the beam splitter*

Key to Figure 86:

A	Attenuator	C	Fixing screw
B	Beam splitter	D	Beam splitter handle

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7. Remove the single fixing screw (C).
8. Remove the beam splitter (B).

Cleaning the Beam Splitter

9. Clean beam splitter in the same way as uncoated optics (see Section 7.6.3 on page 211).

Installing the Beam Splitter

10. Re-mount the beam splitter and tighten the fixing screw
11. Remount the magnetic beam shielding and the mirror access panel.
12. Refit the service panel.
13. Proceed with step 3.

7.7.2.2 Cleaning the Beam Splitter (COMPex*Pro* F_2)

Preparation

CAUTION
Risk of damaging optical components!
Always wear skintight plastic gloves when working on optical components.

1. Switch off the laser device.

WARNING
Unintentional restarting can cause injury or damage!
Always secure the laser device against unintentional restarting when it is completely shut down for maintenance or repair. Before starting work, ensure that the secured by locking out the main switch. Attach appropriate safety tags.

2. Secure the laser device against unintentional restarting (see Section 7.3 on page 176).
3. Use the 3 mm allen key to remove the service panel.

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Removing the Beam Splitter

4. Use a 3 mm allen key to loosen the five fixing screws securing the cover of the bending unit (see Figure 87, A).

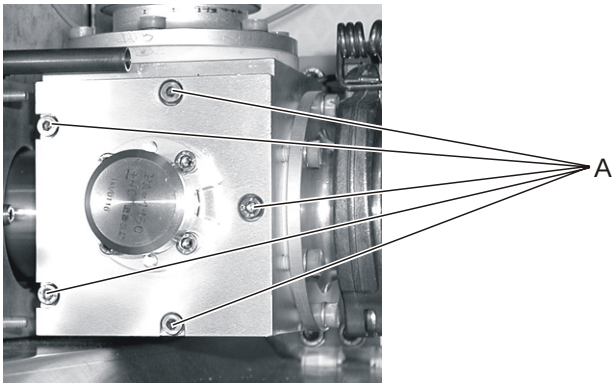


Figure 87: *Energy monitor bending unit (F_2 version)*

5. Carefully pull out the beam splitter (see Figure 88).

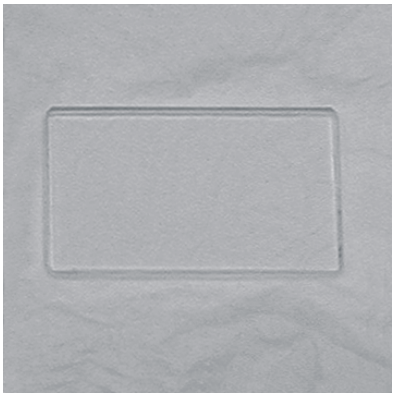


Figure 88: *Beam splitter*

Cleaning the Beam Splitter

6. Clean beam splitter in the same way as uncoated optics (see Section 7.6.3 on page 211).

Installing the Beam Splitter

7. Re-insert the beam splitter into the clamping bracket with slight pressure.
8. Attach the bending unit cover to the bending unit and use a 3 mm allen key to tighten the five fixing screws.
9. Refit the service panel.

A0510COMPPRO

7.7.3 Exchange Energy Monitor Attenuators

Purpose

Exchange the energy monitor attenuators. This is only necessary when the automatic adjustment of the energy monitor signal gain during energy monitor calibration was not successful. This procedure differs for the F_2 version (see Section 7.7.3.2 on page 231). The procedure for all other versions is described in Section 7.7.3.1

NOTE
This procedure is performed as necessary during the energy monitor calibration procedure. Consequently there are no separate lists of maintenance intervals, preconditions, or tools and materials.

7.7.3.1 Changing the Attenuator (COMPex*Pro* 100 / COMPex*Pro* 200)

1. Press <BREAK> to stop the calibration of the energy monitor.
2. Ensure that the laser cannot be restarted.
3. Use the 3 mm allen key to remove the front mirror access cover from the laser device.
4. Remove the (magnetic) beam shielding.

CAUTION
Risk of damaging optical components!
The attenuator is held by two clamps and may be difficult to remove. Do not use tools. Handle the beam splitter with great care. Always wear suitable plastic gloves.

5. If the attenuator is difficult to remove, remove the beam splitter (see steps 5 to 8 on page 227).
6. Change the attenuator (see Figure 86, A on page 227):
   - If the displayed internal calculation value was less than 9.9: Replace with a coarser meshed attenuator (or remove an attenuator if two attenuators were inserted).
   - If the displayed internal calculation value was 20 or higher: Replace with a closer meshed attenuator (or add an appropriate attenuator if necessary).
7. Where necessary, re-insert the beam splitter.
8. Re-insert the (magnetic) beam shielding.
9. Re-insert the front mirror access cover.
10. Proceed with step 3 of the energy monitor calibration procedure (page 225).

A0510COMPPRO

7.7.3.2 Changing the Attenuator (COMPex*Pro* F_2)

1. Press <BREAK> to stop the calibration of the energy monitor.
2. Ensure that the laser cannot be restarted.
3. Disconnect the two FOL's (DATA in and DATA OUT) on top of the energy monitor (see Figure 89, A).

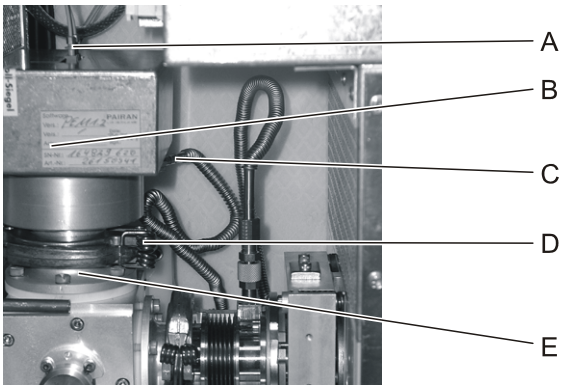


Figure 89: *Energy monitor connection (F_2 version)*

4. Disconnect the purge gas line (C) from the energy monitor.
5. Pull the lever of the clamping ring (D) that clamps the bellows onto the bending unit of the energy monitor.
6. Remove the clamping ring.
7. Carefully remove the energy monitor from the laser housing.

CAUTION
Risk of damaging optical sensitive components!
The attenuator lies in the between the energy monitor and bending unit and might be difficult to remove. Do not use any tools. Always wear suitable plastic gloves.

8. Remove the O-ring between energy monitor and bending unit.
9. Exchange the attenuator (see Figure 89, E).
   - If the displayed internal calculation value was less than 9.9: Replace with a coarser meshed attenuator (or remove an attenuator if two attenuators were inserted).
   - If the displayed internal calculation value was 20 or higher: Replace with a closer meshed attenuator (or add an appropriate attenuator if necessary).
10. Re-insert the O-ring removed in step 8 and reattach the energy monitor onto the bending unit.
11. Attach the clamping ring that clamps the energy monitor onto the bending unit and close the lever to fix the connection.
12. Connect the purge gas line plug to the energy monitor.
13. Connect the two FOL's (DATA IN and DATA OUT) into the sockets on top of the energy monitor.

A0510COMPPRO

14. Attach the service panel to the laser device and tighten the fixing screws.
15. Proceed with step 3 of the energy monitor calibration procedure (page 225).

7.8 Laser Resonator Alignment

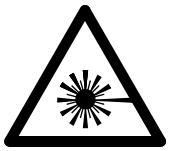
Purpose

Use a visible HeNe or diode alignment laser to align the rear mirror and output coupler so that they are parallel to each other and at right-angles to the laser beam. This is necessary to ensure even energy distribution and a good beam profile.

Prior to aligning the optics, the visible alignment laser has to be adjusted to pass through the exact center of the laser resonator.

NOTE
This procedure only applies when a dielectric coated HR rear mirror is inserted. Aluminum coated mirrors will not transmit the visible light of the alignment laser.

Alternative Methods



WARNING
Risk of injury through laser radiation!
Laser resonator alignment procedures that require working with an open laser beam are only to be performed by authorized persons that have received specific instruction at a COHERENT LAMBDA PHYSIK training course.

In addition to resonator alignment using a visible alignment laser as described in this section, there are other methods of aligning the resonator and optimizing energy distribution and beam profile, e.g. aligning the resonator by optimizing the power output of the laser.

Alternative methods of laser alignment usually require working with an open laser beam. These methods shall only be performed by persons that are authorized and have received specific training at a dedicated Lambda Physik training course. Please contact Lambda Physik for further information.

A0510COMPPRO

Tools and Materials

- Class 2 diode or HeNe (visible) alignment laser

NOTE
Class 2 lasers have a maximum power output of 1 mW. HeNe lasers operate at a wavelength of 632.8 nm (visible red). The wavelength of a diode laser is version dependent. For further information, please refer to the manufacturer's instructions.

- Alignment pucks (from service case)
- Piece of card, on which points of light can easily be seen, with 2 mm pin hole
- 4 mm allen key
- Long 3 mm allen key

Maintenance Interval

- Whenever the tube windows have been cleaned / exchanged

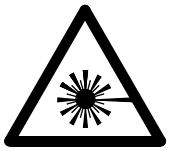
Time Required

- 1.0 h

Preconditions

- Laser device switched off and locked out (see Section 7.3 on page 176).
- Front and rear mirror access covers removed and accessed gained to the front and rear optics.

Setting Up the Visible Alignment Laser



CAUTION
Risk of eye injury!
Do not stare into the beam of a class 2 laser.
Remove all jewelry while performing the alignment procedure.
Never look directly at reflected beams.

1. Direct the visible aligment laser from the rear through the center of the laser cavity (see Figure 90).

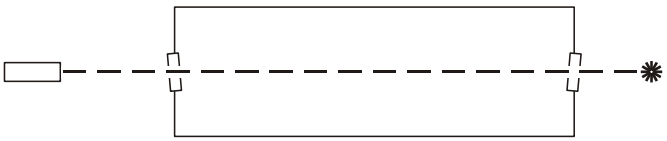


Figure 90: *Direct alignment laser through laser cavity*

NOTE
The electrodes in an excimer laser are very smooth and can easily reflect the light of the alignment laser. It is, therefore, possible to align the laser such that it appears to be on axis when, in fact, it is being reflected off an electrode. This is easily determined by observing the direction in which the alignment laser light moves as you adjust the alignment laser mirror. If you adjust the mirror to move the light to the right, the light at the output side should move to the right. If you make an adjustment to the right and the beam moves to the left, this indicates that the alignment laser beam is being reflected off an electrode.

2. When the alignment laser is roughly on axis with the laser resonator, screw the two plastic alignment pucks into the aperture of each optics mount.

NOTE
The optics can remain installed during this procedure.

3. Adjust the alignment laser until the beam exactly passes through both holes in the alignment pucks (see Figure 91).

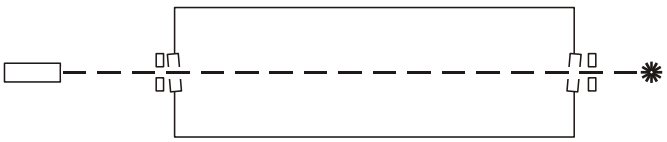


Figure 91: *Direct alignment laser through alignment pucks*

4. Remove the alignment pucks.

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Aligning the Laser Resonator

5. Place the piece of card as close as possible to alignment laser.
6. Position the card so that the beam cleanly passes through the pin hole.

NOTE
Each resonator optic will reflect a small percentage of the alignment laser beam back towards the alignment laser. Depending on the size of the card and initial adjustment of the optics, these two light spots may already be visible on the card (see Figure 92).

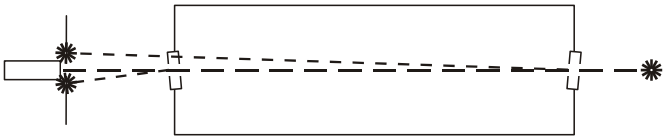

Figure 92: *Reflection of alignment laser on card (alignment necessary)*

7. Use the long 3 mm allen key to adjust the horizontal and vertical adjustment at the output coupler until the reflected light is concentric with the alignment laser beam at the pin hole.
8. Using the long 3 mm allen key, adjust the horizontal and vertical adjustment at the HR rear mirror until the reflected light is concentric with the alignment laser beam and reflected light from the output coupler at the pin hole (see Figure 93).

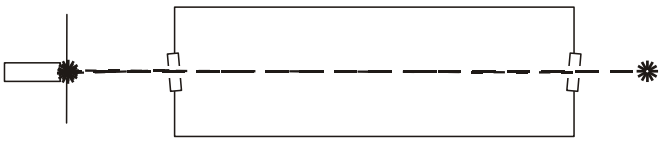

Figure 93: *Reflection of alignment laser on card (optics aligned)*

NOTE
The reflection from the output coupler is dimmer and larger in diameter.

Finalization

9. Re-install the components removed to gain access to the tube optics.

NOTE
The exact procedure depends on the version of the COMPex*Pro*. For further information please refer to the appropriate optics exchange procedure (see Section 7.6 on page 200).

A0510COMPPRO

7.9 Installation and Alignment of Unstable Resonator Optics (Option)

NOTE
Unstable optics are available for the COMPex*Pro* 100 and COMPex*Pro* 200. They are not available for the COMPex*Pro* F_2. The unstable resonator configuration requires the use an Unstable Resonator Adapter.

Purpose

Install and adjust the optics for the COMPex*Pro* unstable resonator.

The unstable resonator is of the positive branch type. The optics set consists of

– a plano-convex calcium fluoride (CaF_2) or magnesium fluoride (MgF_2) mirror as rear optical reflector, which is HR-coated for a specific wavelength,

– an uncoated meniscus lens for the output coupler.

The meniscus lens can be used for different wavelengths. Additional coated plane-convex lenses are required in order to switch to different wavelengths.

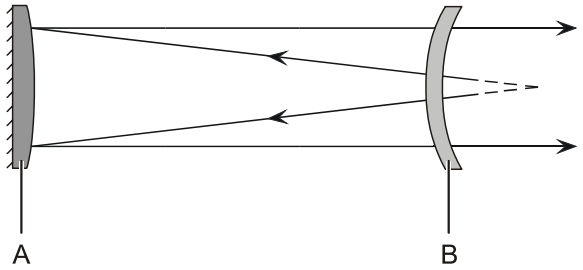

Figure 94: *Setup of the unstable resonator*

The optics, shown in Figure 94, simultaneously seal the cavity of the excimer laser. There are no additional windows installed. The convex surfaces of the optics are always directed to the cavity of the laser tube. The dielectric coating of the rear optics does not come into contact with the laser gas.

The installation of the optics has to follow the same routine as used for a standard optics installation.

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Tools and Materials

- Unstable Resonator Optics
- Unstable Resonator Adapter
- Visible alignment laser (e.g. HeNe laser)
- Piece of card, on which the light reflexes of the alignment laser can easily be seen; with 2 mm pin hole
- Energy meter (e. g. GenTec ED 500 or Coherent LM 100 E)
- Set of Allen keys
- Spanner wrench (in service case)
- Adjustment apertures (in service case)
- Protective eyeware

Preconditions

CAUTION
The laser device is to remain powered up during this procedure! Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements.

- Laser device switched on and laser ready to operate (no radiation being emitted).
- Pressure regulators and cylinder valves in each gas line closed.

Preparation

1. Use the 3 mm allen key to remove the front and rear mirror access panels.

WARNING
Risk of injury through laser radiation!
The laser can be operated when the interlock switches are bridged. Safety interlocks shall only be bridged by authorized persons.

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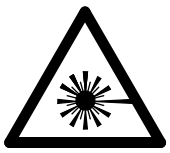
Aligning the Adjustment Laser

When the stable resonator is modified for unstable resonator operation, an alignment laser (e.g. HeNe-laser) has to be adjusted to the aligned laser resonator before dismantling the standard optics. The optics of the unstable resonator fit into the adjustable mounting normally used for the standard direct sealing resonator components.

NOTE
A) The alignment laser beam is directed along the laser tube axis. The resonator optics are set perpendicular to the alignment laser beam by monitoring back the retro-reflections of the alignment beam.
Installing the HeNe-Laser.
B) For further information about removing parts to gain access to the standard optics, please refer to the relevant parts of the “Tube Optics Maintenance” description (Section 7.6 on page 200).

2. Remove the (magnetic) beam shielding .
3. Remove the energy monitor by loosening the 3 mm allen screw and set the energy monitor aside.
4. Install the alignment laser approx. 500 mm in front of the laser device.



CAUTION
Risk of eye injury!
Never directly look into the alignment laser beam or its reflections. Follow the manufacturer’s instructions and local regulations relating to the safe use of alignment lasers.

5. Direct the output of the alignment laser through the center of the laser tube. The alignment laser must pass through the tube without clipping or being or reflected by the electrodes.

NOTE
Tilt the alignment laser tilt upward to determine whether the beam is reflecting off an electrode when being adjusted . If the laser beam moves downward on the beam block, the aligmment laser beam is hitting an electrode.

6. Insert the alignment apertures into the openings directly in front of both of the tube optics.

   The alignment apertures are needed for positioning the alignment laser beam to the optical axis of the excimer laser beam.
7. Move the alignment laser in its position until the beam is centered to the front aperture.
8. Tilt the alignment laser to center the beam through the laser tube to the rear alignment aperture.
   The alignment laser has to pass through the center of both alignment apertures.
9. Fasten the card with pin hole directly in front of the alignment laser, such that the beam passes through the pin hole.

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10. Remove the alignment apertures from the tube optics.
11. Carefully switch off the alignment laser.

Flushing the Laser Tube

12. Close all pressure regulators and gas cylinder valves.
13. Open the valve on the inert gas cylinder.
14. Set the pressure regulator in the inert gas line to the required pressure.
    The gas pressures are indicated in Section 4.2.2. on page 76.
15. Press <PURGE RESERVOIR>.
16. Where necessary, press cursor left or cursor right to select “WIN. EXCHANGE”.
17. Press <ENTER> to confirm the choice.
18. Press <EXE> to proceed.

    The laser tube is evacuated and filled to 1200 mbar with inert gas. Following this, the message “REPLACE WINDOWS (enter)” appears to indicate that the optics are to be exchanged.

Exchange the Tube Optics

CAUTION
Risk of damaging optical components!
There is overpressure in the laser tube. Always hold the optic mount with the other hand while loosening it. Loosen the screws crosswise and in stages. Always wear disposable plastic gloves when handling optical components.

19. Use the 3 mm allen key to loosen the six screws securing the optics mount and then remove the optics mount.
    You will hear a short hissing sound due to the overpressure in the tube. The laser tube is now open.

    The inert gas valve opens every two seconds to compensate for the pressure drop and prevent air from entering the tube.

    When the laser tube is open for longer than one minute, the message ”CLOSE RESERVOIR (enter)“ appears indicating that the sealing plate or replacement optics mount should be inserted.

CAUTION
Risk of damaging laser tube.
The software routine is automatically continued by pressing <ENTER>. Do not press <ENTER> when the tube windows are removed.

20. Immediately mount the sealing plate (see Figure 74 on page 205).

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CAUTION
Risk of damaging optical components!
The optics can easily be damaged while being removed.
Do not drop the optics or let them to come into contact with any metal parts. Always wear disposable plastic gloves when handling optical components

21. Remove the old output coupler from the premount with the spanner wrench tool.
22. Insert the new output coupler into the premount with the concave side facing the thruster ring (for the markings on the output coupler see Figure 95).

NOTE
The orientation of the concave side can be verified by checking if the alignment laser reflection focuses when incident on the concave side.

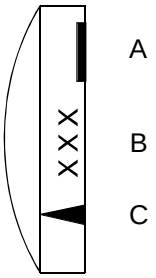

Figure 95: *Marking of the optics*

Key to Figure 95:

A Coated surface
B Wavelength indication
C Arrow pointing towards laser tube

23. Remove the sealing plate from the cavity aperture and immediately attach the mount with the new output coupler to the laser tube and use the 3 mm allen key to tighten the six fixing screws.
24. Lossen the six 3 mm Allen screws of the rear optics mount and remove the optics mount.
    A short hissing sound can be heard due to tube overpressure.
25. Immediately mount the sealing plate (see Figure 74 on page 205).
26. Use the spanner wrench to remove the old rear optics from the optics mount.

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27. Insert the new rear optics into the optics holder and attach it to the external bracket mount.

NOTE
A) When the unstable resonator optics is to be used, the unstable resonator adapter must be fitted. In this case the rear optics must be replaced by an uncoated window which is mounted at an angle of 5°. The plano-convex rear optics is mounted externally to the adapter outside the laser tube.
B) Ensure that the flat, coated side of the optics faces away from the laser tube. This will orientate the convex side toward the laser tube. The convex side may be determined by viewing the curvature of the optic from the side.

28. Remove the sealing plate from the rear cavity aperture and immediately attach the window mount with the new rear optics to the laser tube.

Adjusting the Tube Optics

29. Adjust the window mount for a few turns on the vertical and horizontal axis to ensure that reflections from the window are not on the laser tube axis.
    Observe the reflection of the alignment laser from the output coupler on the punctured card in front of the alignment laser.

NOTE
A) Reflections from each surface from the output coupler may be overlapped and may produce an interference pattern.
B) The beam reflected from the output coupler may be enlarged when the alignment laser is beyond 500 mm away.
C) The reflection of the output coupler is dimmer than the reflection of the rear optics.

30. Center the reflected alignment laser beam through the hole of the pin hole card with the horizontal and vertical adjustment screws on the output coupler mount.
    Observe the reflection of the alignment laser beam from the rear optics on the punctured card in front of the alignment laser.
31. Center the reflected alignment laser beam through the pin hole in the card with the horizontal and vertical adjustment screws on the rear optics mount.

Finalization

32. Reinstall the energy monitor and the magnetic beam shielding.
33. Reinstall the service panel.
34. Press <ENTER> to signify that the tube optics have been exchanged. A new flushing cycle will be started and perform a leak test (see Section 7.6).
35. Refill the laser tube with a new gas fill.
36. Recalibrate the energy monitor (see Section 7.7.1 on page 223).

A0510COMPPRO

7.10 Thyratron Maintenance

Purpose

Check and, if necessary, increase the thyratron supply voltage to compensate for ageing of the thyratron.

NOTE
The procedure described in this section primarily applies to a routine maintenance action. The same procedure can be followed to rectify faults such as missing pulses, no trigger or low beam energy. Take into account the deviations in the procedure when rectifying faults such as additional pulses and overload.

Maintenance Interval

- Every 300 million pulses

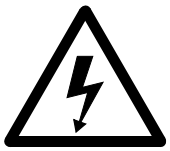
Time Required

- 0.25 h

Tools and Materials

- 3 mm allen key
- TRMS Voltmeter (TRMS=True Root Mean Square)
- Laser logbook

Preconditions



CAUTION
The laser device is to remain powered up during this procedure! Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements.

- Laser device switched on and laser ready to operate (no radiation being emitted).

Preparation

1. Use the 3 mm allen key to remove the thyratron adjustment plate cover.

NOTE
If one of the jumpers is already at the maximum setting on the thyratron adjusment plate, the thyratron or hydrogen reservoir is exhausted. In this case, contact Lambda Physik service.

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Measure the Heating Voltages (U_H and U_R)

NOTE
The specified range for the heating voltage is 6.3 to 6.7 V. If the voltage is considerably outside of this range, the supply voltage will need to be increased or decreased. Ageing of the thyratron causes a decrease in the heating voltage which is compensated for by increasing the supply voltage.

2. Use the TRMS voltmeter to measure the heating voltage of the thyratron (U_H) between the jacks GND and HEAT (see Figure 96).

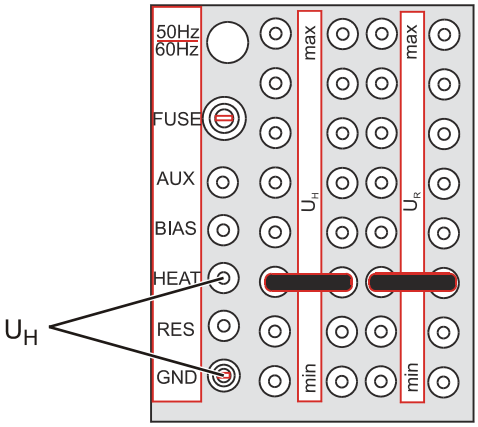

Figure 96: *Measuring thyratron heating voltage*

3. Note the measured value.
4. Measure the heating voltage of the hydrogen reservoir (U_R) between the jacks GND und RES (see Figure 97).

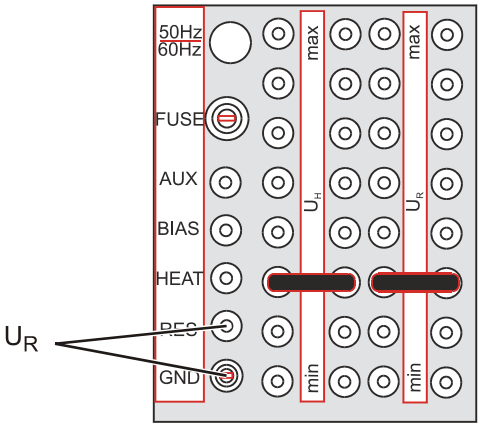

Figure 97: *Measuring reservoir heating voltage*

5. Note the measured value.

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Measure the Bias (U_{BIAS})

NOTE
Note that U_{BIAS} is a DC value. The voltage has to be between -150 V and -160 V. If this is not the case, the varistor is exhausted. In this case, contact Lambda Physik service.

6. Measure U_{BIAS} between the jacks GND and BIAS.
7. Note the measured value.
8. Measure U_{BIAS} between the jacks GND und AUX.
9. Note the measured value and, if necessary, contact Lambda Physik service.

Increase the Supply Voltage

NOTE
Steps 11 to 15 only apply to routine maintenance or the rectification of faults such as missing pulses, no trigger or low beam energy. To rectify additional pulses or if the error message OVERLOAD occurs, perform steps 16 to 23.

10. Remove the U_H and/or U_R jumpers and insert at the next highest setting (see Figure 98).

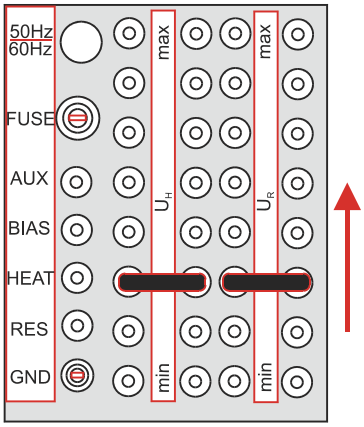

Figure 98: *Thyratron supply voltage adjustment*

11. Start the laser.
12. Wait at least three minutes for the thyratron to reach a thermally stable state. If additional pulses should occur, decrease UR one step.
13. Measure U_H between GND and HEAT again.
14. Measure U_R between GND and RES again.
15. Note the new values and compare them with the previously recorded values.

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Decrease the Supply Voltage

NOTE
Steps 16 to 23 only apply if faults such as additional pulses or the error message OVERLOAD occurs.

16. Remove the U_R jumper and insert at the next lowest setting (opposite the direction to the arrow, see Figure 98 on page 244).
17. Start the laser.
18. Wait at least three minutes for the thyratron to reach a thermally stable state.
19. Measure U_R between GROUND and RES again.
20. Note the new value.
21. Start laser operation at the lowest possible HV value for stable energy output.
22. Operate the laser for five minutes at max. repetition rate.
23. Increase the HV value in steps of 1 kV every five minutes until the max. HV value is reached and operate the laser at max. HV for 15 minutes.

    If no additional pulses occur, the thyratron is adjusted. Otherwise, return to step 16 and repeat the procedure.

Finalization

24. Use the 3 mm allen key to refit the thyratron adjustment plate cover.

7.11 Halogen Filter Maintenance

Lambda Physik excimer lasers use a halogen filter to remove molecular species of fluorine from laser gas mixtures removed from the laser tube.

Storage

Filters must be stored in unopened packaging in accordance with all relevant regulations. According to the accident prevention regulation “Protection from Hazardous Chemical Substances (VBG 1a, FR Germany)”, unopened filters can be stored for a period of up to four years. The filter’s lifetime is printed on the packaging. Filters should always be stored in a dry place in the original, unopened packaging, to protect from damage. A Filter with visible damage (e.g. dents) must be removed regardless of its shelf life.

A0510COMPPRO

7.11.1 Check Halogen Filter Filling Ratio

Purpose

Check the filling level of the halogen filter. At a filling level of 100 % the halogen filter has to be exchanged (see Section 7.11.2).

Maintenance Interval

- Every 4 weeks
- Before a new gas fill

Time Required

- 0.05 h

Tools and Materials

- None

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).

Checking the Halogen Filter Filling Ratio

1. Press <F4> on the handheld keypad.
2. Read off the filling ratio.
3. Press <BREAK> to terminate the function.

NOTE
Make sure that a replacement halogen filter is available in good time.

7.11.2 Exchange Halogen Filter Cartridge

Purpose

Exchange the halogen filter cartridge when the filling capacity has been reached.

The halogen filter is situated in the aluminum housing above the vacuum pump.

Maintenance Interval

- When indicated by the laser control software

Time Required

- 0.25 h

A0510COMPPRO

Tools and Materials

- Housing key
- Set of Allen keys
- Pliers
- Replacement halogen filter

WARNING
Toxic hazard!
The halogen filter contains fluorine and/or chloride components.
Keep the filter in a well ventilated place.
Wear safety glasses and gloves.

- Sealable plastic bag
- Plastic gloves
- Safety glasses

Preconditions

- Laser device switched on and laser ready to operate (no radiation being emitted).

Preparation

CAUTION
Toxic hazard!
The vacuum line may contain halogen. To ensure that there is no halogen in the line, always purge the line before removing the halogen filter.

1. Use the ”PURGE INERT LINE“ procedure to purge the inert gas line and vacuum line (see Section 7.4.2 on page 180).

   The vacuum pump will extract the inert gas through the vacuum line and halogen filter.
2. Shut down and secure the laser device (see Section 6.2.6 on page 158).

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Removing the Halogen Filter Cartridge

3. Remove the four wing nuts (see Figure 99, A) and washers (B) from the top of the halogen filter housing .

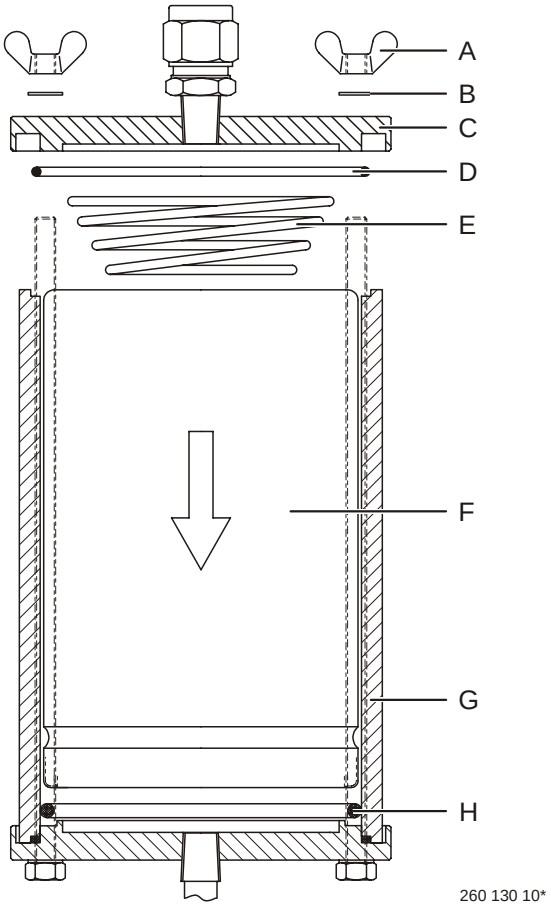

Figure 99: *Exchanging the halogen filter*

Key to Figure 99:

A	Wing nut	E	Spring
B	Washer	F	Filter cartridge
C	Housing cover	G	Housing
D	Top O-ring	H	Lower O-ring

4. Lift the top cover (C) off of the filter housing.
5. Remove the spring (E).
6. Use the pliers to lift out the filter cartridge (F).
   Take care not to remove the bottom o-ring (H).
7. Check the condition of the upper and lower o-rings in the filter housing. Replace the o-rings if damaged.

NOTE
The arrow in Figure 99 indicates the direction of flow of the gas.

A0510COMPPRO

Inserting the New Halogen Filter

8. Place the new filter cartridge (F) into the filter housing (G). Ensure that the arrow on the filter cartridge points downwards.
9. Place the spring (E) on top of the filter cartridge.
10. Refit the top (C) of the filter housing.
11. Place the washers (B) on each of the threaded rods
12. Fit the four wing nuts (A) and hand tighten.

Finalization

13. Switch on the laser device (see Section 6.2.3 on page 153).
14. Press <F4> on the hand-held terminal.
15. Press the numerical button <0> to reset the filter filling ratio and press <ENTER> to confirm.

Filter Cartridge Disposal

WARNING
Toxic hazard!
The halogen filter may contain halogen gas that has not reacted. Therefore, for safety reasons, a storage period prior to disposal is necessary . Observe the storage period and pre-disposal procedure indicated in this section and the information in the filter packaging.

16. Store the filter cartridge for 6 hours in a well-ventilated location.
17. Immerse the filter cartridge in 10 liters of water for 24 hours.
18. Place the filter cartridge inside the plastic bag removed from the new filter and seal the bag by means of the supplied twist-tie.
19. Dispose of the filter cartridge in accordance with local regulations.
20. Dispose of the water according to all locally applicable regulations.

NOTE
Local waste water regulations may require that the water be neutralized. For neutralization, use calcium hydroxide if the pH value is less than 7 or acetic acid if the pH value exceeds 7.

A0510COMPPRO

7.12 Preparation for Transport / Storage

During transportation or longer periods of non-operation (e.g. storage), gases can enter

– the laser tube and damage the passivation layer,

– the gas lines and cause corrosion.

To prevent this, the laser tube has to be filled with a transportation fill and the gas lines have to be sealed.

7.12.1 Transportation Fill

Fill the laser tube with a transportation gas filling when the laser device is to be transported or is not to be used for a longer period of time. The transportation fill routine evacuates the laser tube and fills it to 1500 mbar with buffer gas.

Maintenance Interval

- Before transportation
- Before storage

Time Required

- 0.25 h

Tools and Materials

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Buffer gas as specified (see Section 4.2.2 on page 76). Gas cylinder with a remaining pressure of at least 10 bar (abs.) connected to the buffer gas connection of the laser device.

A0510COMPPRO

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- All gas cylinder valves and pressure regulators closed

Performing a Transport Fill

1. Open the buffer gas cylinder valve.
2. Set the pressure regulator in the buffer gas line to the specified value. (see Section 4.2.2 on page 76).
3. Press <F6>.
   The bottom line of the handheld keypad display shows a selection of options.
4. Press <Cursor Right> and/or <Cursor Left> to select “TRANSPORT”.
5. Press <ENTER> to confirm the selection.
6. Press <EXE> to start the transport gas filling.
   The tube is evacuated and filled to 1500 mbar with buffer gas.

NOTE
A) Only interrupt the procedure by pressing <BREAK> in case of an emergency. As the procedure will be immediately interrupted and the fill is incomplete, there may be insufficient pressure in thelaser tube. In this case, restart the transportation fill.
B) The message ”SAFETY FILL“ appears if the evacuation was unsuccessful (the remote command OPMODE? returns the reply SAFETY FILL). As there is most likely a leak, a safety fill will be automatically started.

7.12.2 Disconnect Gas Lines

Purpose

The gas supply lines are to be disconnected when de-installing, transporting and storing the laser device. To prevent corrosion in the gas system, the halogen gas in the lines has to be replaced by inert gas before the lines are separated.

A0510COMPPRO

Tools and Materials

- 9/16 inch wrench
- 13 mm wrench
- Gyrolok stainless steel cap to seal the gas lines.
- Stainless steel plugs included with the laser device to seal the connections on the laser device.

CAUTION
Incorrect handling will cause unnecessary downtime!
Only use gas cylinders with a remaining pressure of more than 10 bar (abs.) to ensure that there is an adequate gas supply to perform gas actions. Depending on the configuration of the gas system, pressures of below 20 bar (abs.) may be critical.

- Inert gas as specified (see Section 4.2.2 on page 76). Gas cylinder with a remaining pressure of at least 10 bar (abs.) connected to the inert gas connection of the laser device.

Preconditions

CAUTION
The laser device is to remain powered up during this procedure!
Ensure that the maintenance area is at all times adequately secured and that no unauthorized persons can access the laser device.
All persons in the maintenance area shall be fully familiar with the applicable safety regulations and requirements

- Laser device switched on and laser ready to operate (no radiation being emitted).
- All gas cylinder valves and pressure regulators closed

Disconnecting the Gas Lines

1. Purge the halogen gas line (see Section 7.4.2 on page 180).
2. Ensure that the halogen gas cylinder valve and pressure regulator are closed.
3. Use the 9/16“ wrench to disconnect the halogen gas line from the Gyrolok® fitting on the laser head.

CAUTION
Risk of gas line corrosion!
The gas lines can corrode if air and humidity penetrate into them.
Prevent air and humidity penetration by sealing the connections on the laser head and gas lines with the corresponding plugs and caps. The gas line connections should always be sealed before transporting or storing the laser device

A0510COMPPRO

4. Seal the gas connection on the laser device with the corresponding plug.
5. Seal the gas supply line with the corresponding cap. The sealed lines may remain in this state for a longer period of time now.
6. Repeat steps 3 to 5 to disconnect and seal the other gas lines.

A0510COMPPRO

8 CONTROL SOFTWARE

This chapter is intended for programmers who want to develop a user shell to remotely control the COMPex*Pro* with an external computer system through the communication interface (CI).

The following sections describe the operating modes and commands that are required to control the laser device through the RS232 serial interface. These commands can either be sent through the handheld keypad provided with the laser device or through an external computer system.

NOTE
Familiarize yourself with the fundamantal procedures required to operate and maintain the COMPex*Pro*, as described in chapters 6 and 7, before working with this chapter.

The software described in this chapter is the COMPex*Pro* software version 4.8. The software version that is currently installed on your laser device can be called though the polling command ”VERSION?“ .

NOTE
The COMPex*Pro* F_2 series is supplied with software version 4.83. When an upgrade from version 4.82 to 4.83 is planned, the EPROM in the basic module of the Communication Interface has to be replaced by the new version “CPX BM01 V2.2“.

A0510COMPPRO

8.1 Communication Syntax

All commands are case insensitive text commands. Each command is terminated with the <CR> (Carriage Return) character.

Two fundamental types of commands are used:

- Setting commands:
  These are used to set laser operating modes or laser parameters.
- Polling commands:
  These are used to call the current laser status or parameter setting.

Setting Commands

Command syntax:	*name*=*setting*<CR>
Example:	The command OPMODE=OFF<CR> has to be sent to the communication interface (CI) to switch off the laser.

Polling Commands

Command syntax:	*name*?<CR>
Reply syntax for operating modes:	*setting*<CR> *setting*:*status*<CR>
Example:	The command OPMODE?<CR> has to be sent to the communication interface to find out the current operating mode of the laser. If the laser is ready for operation but at present switched off, the CI will send the reply OFF:0<CR>.

NOTE
The CI does not send a reply code after receiving a setting command. To ensure that the setting command is valid and has been correctly processed, send the corresponding polling command immediately after sending the setting command.

A0510COMPPRO

Syntax Description

name	The name OPMODE (to indicate an operating mode) or one of the parameter commands listed in Section 8.3.1. This can be either a setting command or a polling command.
setting	A word or numerical value that defines an operating mode or parameter setting. With numerical values, the character X in the descriptions in this chapter indicates each permitted place in the value (i.e. each digit between 0 and 9). Less positions or leading zeros are permitted. If the value has to be within a permitted range of values, this range is indicated in the respective command description. When a numerical value is to contain a special character (e.g. colon or decimal point), this is also indicated in the respective command description. Where more than one word or numerical value is required, the information separator is a comma.
status	One of the status codes listed in Section 8.2.4 on page 270.
=	Equals sign. This is always written between the name and setting in both setting commands and replies to polling commands.
?	Question mark. This is always written at the end of a command to indicate a polling command.
:	Colon. This is written as information separator between a setting and a status code.
<CR>	Carriage Return character. This is always inserted after each polling command, setting command or reply to terminate the command. The insertion of this character is assumed in the command syntax descriptions in the remainder of this chapter.

NOTE
Do not insert a blank before or after an equals sign, question mark, comma or CR character. If a blank is required within a command, this is indicated in the syntax of the individual command description.

A0510COMPPRO

8.2 Operating Modes

The operating modes of the COMPex*Pro* are changed and called through OPMODE commands (OPMODEs = “Operating Mode“) . In most cases, a change of operating mode will not influence the settings of the parameters.

The operating modes are changed with the command ”OPMODE=“ and the status is called through the polling command ”OPMODE?“ . The reply (*setting,status*) indicates the currently active operating mode and, where applicable, the status code.

8.2.1 Overview of Operating Modes

The available operating modes are listed in the following:

OPMODE	Function	Description
OFF	Switches the laser off	Section 8.2.3.1
ON	Switches the laser on to run with the currently active operating parameters	Section 8.2.3.2
SKIP	Interrupts the thyratron warm-up phase	Section 8.2.3.3
NEW FILL	Evacuates the laser tube and fills it with fresh laser gas	Section 8.2.3.4
PASSIVATION FILL	Evacuates the laser tube and fills it with a gas mixture for tube re-passivation (Halogen/Helium)	Section 8.2.3.5
PURGE RESERVOIR	Evacuates the laser tube and fills it with inert gas for purging	Section 8.2.3.6
SAFETY FILL	Fills the laser tube with inert gas in case of a leak	Section 8.2.3.7
TRANSPORT FILL	Evacuates the laser tube and fills it with buffer gas (Neon) for transport	Section 8.2.3.8
FLUSHING	Evacuates the laser tube and fills it with an inert gas to exchange the optics	Section 8.2.3.9
CONT	Continues the optics change procedure with a leak test	Section 8.2.3.10
HI	Injects halogen gas into the laser tube (HI)	Section 8.2.3.11
PGR	Exchanges part of the laser gas (PGR = partial gas replacement)	Section 8.2.3.12
MANUAL FILL INERT	Fills the laser tube for 10 seconds with inert gas	Section 8.2.3.13
FLUSH <xy> LINE	Evacuates the <xy> gas line for 2 seconds	Section 8.2.3.14
PURGE <xy> LINE	Evacuates the <xy> gas line for 5 seconds and fills it with inert gas	Section 8.2.3.15
CAPACITY RESET	Resets the filling level indicator for the halogen source	Section 8.2.3.16
LL OFF	Deactivates the low light function	Section 8.2.3.17
ENERGY CAL	Starts the routine for calibrating the energy monitor	Section 8.2.3.18

A0510COMPPRO

8.2.2 Operating Mode Setting Restrictions

In some cases operating commands will not be accepted. The table below indicates, depending on the current operating mode, if an operating command is accepted (yes) or refused (no).

Current OPMODE	Operating Mode (OPMODE) Received)						
	Off	On	HI / PGR	New Fill	Manual Fill Inert	Purge <xy> Line [a]	Purge Reservoir
Off	yes	yes	no	yes	yes	yes	yes
On	yes	no	yes[b]	no	yes	no	no
HI / PGR	yes	no	no	no	no	no	no
New Fill	yes	no	no	no	no	no	no
Manual Fill Inert	yes	no	yes	no	no	no	no
Purge / Flush <xy> Line	yes	no	no	no	no	no	no
Purge Reservoir	yes	no	no	no	no	no	no

a. the restrictions also apply for the command FLUSH <xy> LINE
b. will only be accepted if a gas action (HI/PGR) is necessary

NOTE
Commands to execute service routines (Flushing, Transport Fill, Passivation Fill etc.) will only be accepted in the Off mode.

A0510COMPPRO

8.2.3 Description of Operating Modes

This chapter describes the various operating modes as well as the commands that are to be used to change the mode and poll the current status.

8.2.3.1 OFF

In this mode the laser device is switched on and the laser controller is active. No action will be executed. this condition is activated:

– automatically after switching on the laser device,

– from the laser mode On, when the command to switch off the laser is sent,

– automatically after an interlock.

From the Off-mode, laser operation can be started and maintenance actions can be executed.

Syntax:

Setting:	OPMODE=OFF
Polling:	OPMODE?
Reply:	OFF WAIT OFF:aa

Syntax Description:

WAIT	During laser start-up: the laser waits for power supply standby and the gas circulation fan to start (duration: approx. 5 seconds)
aa	Status code (see Section 8.2.4 on page 270)

A0510COMPPRO

8.2.3.2 ON

In this mode, the laser is switched on. Light pulses will be generated and emitted according to the currently active laser parameters. This mode is selected from the Off mode when the command to start the laser is sent. During the start delay period (see Section 8.2.3.1: OFF,WAIT) the laser start can be terminated by sending the command ”OPMODE=OFF“.

Syntax:

Setting:	OPMODE=ON
Polling:	OPMODE?
Reply:	ON ON:aa

Syntax Description:

aa	Status code (see Section 8.2.4 on page 270)

Status Code Priorities

It is possible that two or more ON status codes apply simultaneously. In this case the COMPex*Pro* replies with the ON code with the highest priority.

The priority for each code is listed in the following table. A higher number corresponds to a higher priority. If two ON codes have the same priority, the COMPex*Pro* displays the first ON code to occur.

Prioritity	**Message**	**Meaning**
5	ON:03	Duty Cycle exceeded
4	ON:9	NO VACUUM
	ON:10	LOW PRESSURE
	ON:13	FLUORINE VALVE NOT OPEN
3	ON:2	PRESET ENERGY TOO HIGH
	ON:8	NEW GAS FILL NEEDED
	ON:40	PRESET ENERGY TOO LOW
2	ON:34	HI (halogen injection) in preparation
1	ON:36	COD (Charge On Demand) ON
	ON:37	COD on at repetition rate >50 Hz
0	ON	Laser on, no warning message
	ON:0	Laser on, no warning message

For all other codes there are no priorities. This means that the last code displayed is the most current and the previous code has been deleted.

A0510COMPPRO

8.2.3.3 SKIP

After initially switching on the laser device (mains on), the thyratron will be warmed up in readiness for laser operation. The Skip command terminates the warm-up period. If, however, the thyratron warm-up period is skipped, the laser will not optimally perform (missing pulses or no pulses!).

Syntax:

Setting:	OPMODE=SKIP

8.2.3.4 NEW FILL

The laser tube is evacuated and filled with fresh laser gases.

Syntax:

Setting:	OPMODE=NEW FILL
Polling:	OPMODE?
Reply:	NEW FILL NEW FILL,XXXX NEW FILL:3

Syntax Description:

XXXX	Status	
	EVAC	Laser tube being evacuated
	WAIT	Leak test or halogen source being warmed up
	FILL	Laser tube being filled
3	Status code 3 (no gas flow)	

A0510COMPPRO

8.2.3.5 PASSIVATION FILL

The laser tube is evacuated and filled with halogen gas so that the tube can be re-passivated.

Syntax:

Setting:	OPMODE=PASSIVATION FILL
Polling:	OPMODE?
Reply:	PASSIVATION FILL PASSIVATION FILL:3

Syntax Description:

3	Status code 3 (no gas flow)

8.2.3.6 PURGE RESERVOIR

The laser tube is evacuated and filled (purged) with inert gas.

Syntax:

Setting:	OPMODE=PURGE RESERVOIR
Polling:	OPMODE?
Reply:	PURGE RESERVOIR PURGE RESERVOIR:3

Syntax Description:

3	Status code 3 (no gas flow)

A0510COMPPRO

8.2.3.7 SAFETY FILL

This OPMODE can only be sent by the Communication Interface. The safety fill is started when the permissible period for the evacuation of the laser tube is exceeded (30 mbar is not reached within 11.5 minutes). The laser tube is automatically filled to 1050 mbar with the gas connected to the ”Buffer“ connection (Neon).

Syntax:

Setting:	OPMODE=SAFETY FILL
Polling:	OPMODE?
Reply:	SAFETY FILL SAFETY FILL:3

Syntax Description:

3	Status code 3 (no gas flow)

8.2.3.8 TRANSPORT FILL

The laser tube is evacuated and filled for transport or storage to 1050 mbar with the gas connected to the ”Buffer“ connection (Neon).

Syntax:

Setting:	OPMODE=TRANSPORT FILL
Polling:	OPMODE?
Reply:	TRANSPORT FILL TRANSPORT FILL:3

Syntax Description:

3	Status code 3 (no gas flow)

A0510COMPPRO

8.2.3.9 FLUSHING

This routine is required to exchange the tube windows. The laser tube is evacuated and filled to 1050 mbar with inert gas. After exchanging the optics, a leak test is carried out and the laser tube is then filled with fresh laser gas.

Syntax:

Setting:	OPMODE=FLUSHING
Polling:	OPMODE?
Reply:	FLUSHING FLUSHING XXXX FLUSHING:aa FLUSHING XXX:aa

Syntax Description:

XXXX	Status	
	CONT	the routine enables the window exchange and waits for the command to continue
	LEAKTEST	Leak test after window exchange
	LEAKTEST CONT	the routine waits for the command to continue after the leak test
aa	Status code	
	3	No gas flow
	30	The laser tube is not leak tight

8.2.3.10 CONT

The window exchange routine stops twice to wait for user intervention. This command continues the routine after exchanging the optics and successfully completing the leak test.

Syntax:

Setting:	OPMODE=CONT

A0510COMPPRO

8.2.3.11 HI

A halogen injection (HI) is carried out to refreshen the laser gas. The partial pressure of the halogen to be injected is indicated in the gas menu. With the halogen source, this command is executed after a warm-up period of 3 minutes.

Syntax:

Setting:	OPMODE=HI
Polling:	OPMODE?
Reply:	HI

8.2.3.12 PGR

A PGR (*P*artial *G*as *R*eplacement) is carried out to refreshen the laser gas. A portion of the gas in the laser tube is replaced by fresh gas. The partial pressure of the gases to be filled is indicated in the gas menu. With the halogen source, this command is executed after a warm-up period of 3 minutes.

Syntax:

Setting:	OPMODE=PGR
Polling:	OPMODE?
Reply:	PGR

8.2.3.13 MANUAL FILL INERT

Inert gas will be filled into the laser tube for 10 seconds. This command will only be accepted up to a tube pressure of 3000 mbar.

Syntax:

Setting:	OPMODE=MANUAL FILL INERT
Polling:	OPMODE?
Reply:	MANUAL FILL INERT

A0510COMPPRO

8.2.3.14 FLUSH <XY> LINE

A gas line will be evacuated for 2 seconds. <XY> indicates the name of the line: BUFFER, HALOGEN, INERT or RARE.

Syntax:

Setting:	OPMODE=FLUSH <XY> LINE
Polling:	OPMODE?
Reply:	FLUSH <XY> LINE

Example:

Evacuating the halogen gas line:

OPMODE=FLUSH HALOGEN LINE<CR>
OPMODE?<CR>
FLUSH HALOGEN LINE<CR>

8.2.3.15 PURGE <XY> LINE

A gas line will be evacuated for 5 seconds and then filled for 2 seconds with inert gas. <XY> indicates the name of the line: BUFFER, HALOGEN, INERT or RARE.

Syntax:

Setting:	OPMODE=PURGE <XY> LINE
Polling:	OPMODE?
Reply:	PURGE <XY> LINE

Example:

Purging the halogen gas line:

OPMODE=PURGE HALOGEN LINE<CR>
OPMODE?<CR>
PURGE HALOGEN LINE<CR>

A0510COMPPRO

8.2.3.16 CAPACITY RESET

This command sets the filling level indicator of the halogen source to the value specified through the parameter command ”CAP.SET=“ .

Syntax:

Setting: OPMODE=CAPACITY RESET

Example:

Set the halogen source filling level indicator to 100 %

CAP.SET=120<CR> (see Section 8.3.8.2, page 289)

Reset the filling level indicator to the indicated value

OPMODE=CAPACITY RESET<CR>

8.2.3.17 LL OFF

This command deactivates the Low Light function. When the Low Light function is active (default choice), laser operation is interrupted when more than 30 % of laser pulses are missing within a 10 second period. The Low Light OFF function (LL OFF) will not interrupt laser operation when there are missing pulses and should, therefore, only be used for diagnostic purposes.

OPMODE=LL OFF is only accepted when OPMODE=OFF is active (see Section 8.2.3.1 on page 260). LL OFF is a one shot command. After setting LL OFF, the Low Light function will be deactivated for the next laser operation started through OPMODE=ON. When this laser operation is terminated through OPMODE=OFF, LL OFF will be automatically cancelled. The default low light function will be automatically active for the following laser operation started through OPMODE=ON.

Syntax:

Setting: OPMODE=LL OFF

8.2.3.18 ENERGY CAL

The energy monitor will be calibrated. The functional sequence of the routine when cotrolling the laser device through an external PC is indicated in Figure 100 on page 269. The steps are indicated in the rectangles, the necessary commands are written in capital letters next to the corresponding steps.

A0510COMPPRO

Syntax:

Setting:	OPMODE=ENERGY CAL
Polling:	OPMODE?
Reply:	ENERGY CAL ENERGY CAL CONT

Syntax Description:

CONT	The routine waits for the input of a reference energy through the command ”EGY=“ or „EGY SET=“ (see Section 8.3 on page 272)

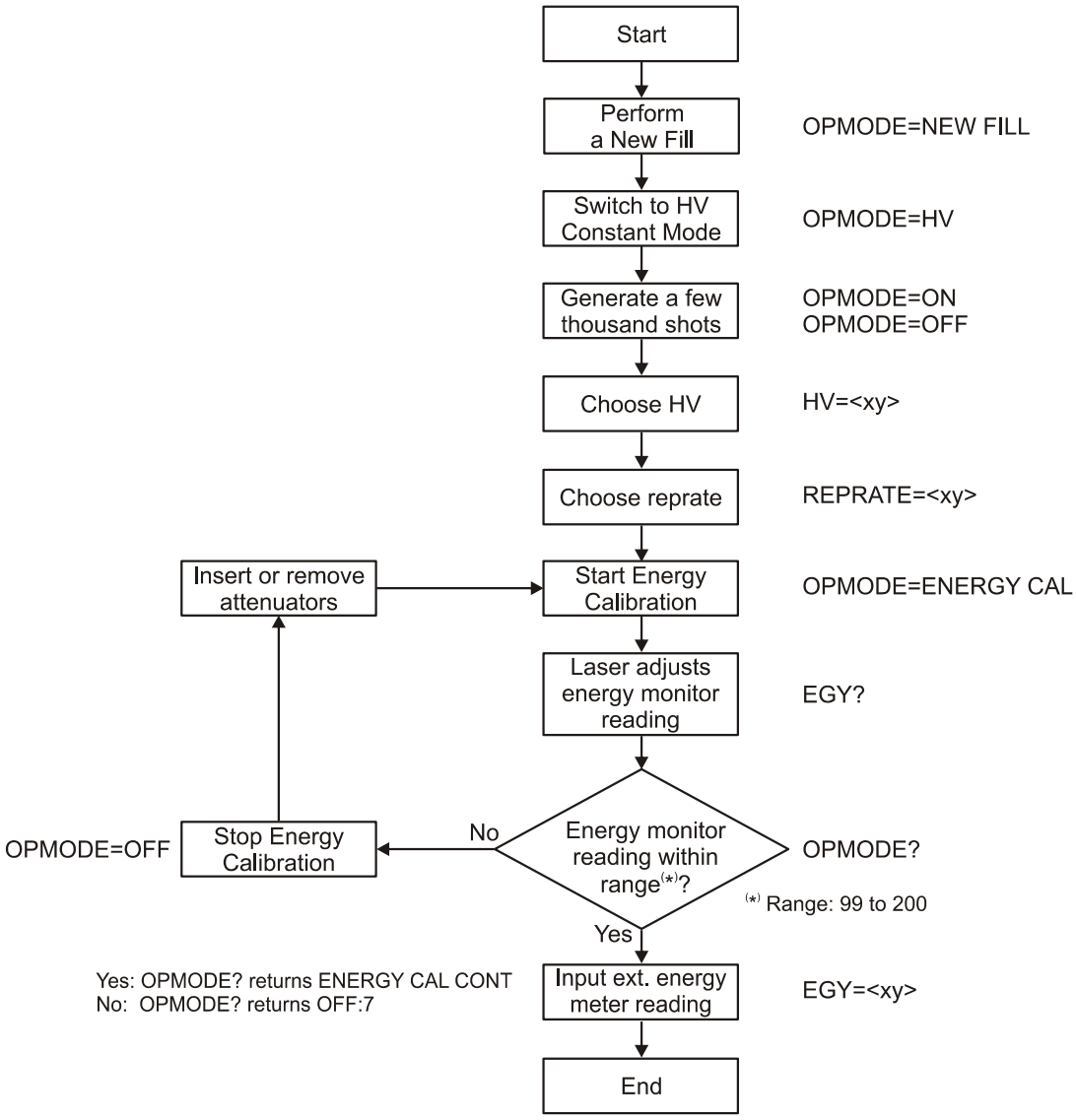

Figure 100: *Calibrating the energy monitor*

A0510COMPPRO

8.2.4 Status Codes

Depending on the configuration of the laser device, the following status codes may be appended to the reply to an operating mode polling command (OPMODE=?)

No.	Description
0	No message, warning or interlock active
1	Interlock
2	PRESET ENERGY TOO HIGH HV loading voltage exceed HV_{max}
03	DUTY CYCLE (only with some laser devices) The duty cycle has been exceeded (more than 12,000 pulses in 20 minutes)
3	NO GASFLOW
4	A WATCHDOG has been activated
5	FATAL ERROR Error in the FOL data ring
6	POLLING At least one laser module does not reply
7	ENERGY CAL. ERROR The energy monitor signals are outside of the permissible range, the automatic signal amplification setting is malfunctioning
8	NEW GAS FILL NEEDED A new gas filling is necessary as the loading voltage exceeds HV_{max}
9	NO VACUUM The laser tube was unable to be evacuated. A safety gas fill was successfully carried out. All activities were interrupted
10	LOW PRESSURE (only with fluorine source) As the sixth fluorine filling was unsuccessful (low pressure), it is assumed that the fluorine source is empty
11	NO CAPACITY LEFT (only with halogen source) The halogen source is empty
12	ERROR TEMPERATURE MEASUREMENT (only with a halogen source) Error with the measurement of the halogen source temperature
13	FLUORINE VALVE NOT OPEN (only with a fluoring source) The fluorine source valve is closed or a fault has occurred during the filling procedure
21	WARM-UP 8min The thyratron is being warmed up.
26	LOW LIGHT The beam energy is too low. The energy monitor does not detect laser pulses after the trigger pulses (at least 30% of all pulses within a period of 10 seconds are missing).

(Sheet 1 of 2)

A0510COMPPRO

No.	Description
27	WRONG PRESSURE The tube pressure is not within the permissible range (± 20 % outside of the tube pressure specified in the gas menu).
29	Memory check malfunction. The gas data is lost
30	A leak in the laser tube has been detected after an optic change
31	TIMEOUT There has been no data transmitted through the RS232 within a second
33	HALOGEN PRESSURE TOO HIGH (only halogen source) The preset partial pressure for the halogen in the gas menu is too high for a halogen source (> 15 mbar)
34	HI IN PREP (only halogen source) A halogen injection is being prepared
35	NOT AVAILABLE (only halogen source) A function has been selected that is not available with the halogen source (e. g. the EGY PGR mode)
36	Charge On Demand (COD) is switched on
37	WARNING! REPRATE FOR COD > 50 Hz Charge On Demand (COD) is active and the repetition rate entered is higher than 50 Hz. The repetition rate has been reduced to the highest value permissible for COD of 50 Hz
39	INERT VALVE CLOSED The internal valve has been closed after a manual fill with inert gas, reason: the valve was open for 10 seconds or the tube pressure exceeds 3800 mbar.
40	PRESET ENERGY TOO LOW The beam energy entered is too low. The laser is running with the lowest HV, but the beam energy is still higher than the preset value.
41	The entered energy value exceeds the value defined in the menu data by more than 5 %.

(Sheet 2 of 2)

A0510COMPPRO

8.3 Laser Parameter Commands

To set or change laser operating parameters, parameter commands are used. The laser parameters are set or changed with the command *name=setting* and read with the polling command *Name*?.

8.3.1 Overview of Laser Parameters

The following table lists (in alphabetical order) the parameters that can be read (r) or set (s).

Name	Format	Unit	Access read/ set	Function	Description
ACCU	XXXX	mbar	r	Halogen source accumulator pressure	Section 8.3.8.1
BUFFER	XXXX	mbar	r/s	Buffer gas partial pressure	Section 8.3.5.2
CAP.LEFT	XXX	%	r	Remaining volume of halogen source	Section 8.3.8.2
CAP.SET	XXX	%	s	Volume of halogen source	Section 8.3.8.2
COD	ON or OFF	—	r/s	COD function active or inactive	Section 8.3.7.1
COUNTER	XXXXX or RESET	10^3 pulses	r s	Resettable counter reading Reset the counter reading	Section 8.3.6.2
COUNTS	XXXXX	pulses	r/s	Amount of pulses for external triggering	Section 8.3.4.7
EGY	XXX.XX	mJ	r/s	Set value for beam energy in the EGY Const mode	Section 8.3.4.2
EGY SET	XXX.XX	mJ	r/s		
EGY RANGE	XXX	%	r/s	Tolerance range for beam energy	Section 8.3.4.3
FILTER	XX	pulses	r/s	Amount of pulses to calculate the average beam energy	Section 8.3.7.2
FILTER CONTAMINATION	XXX or RESET	% —	r s	Halogen filter filling level Reset filling level to zero	Section 8.3.7.3
GASMODE	SINGLE GASES or PREMIX	—	r/s	Gas mode: - Single gases - Gas mixtures (premix)	Section 8.3.5.1
HALOGEN	XXXX	mbar	r/s	Halogen gas partial pressure	Section 8.3.5.2
HV	XX.X	kV	r/s	Preset value for loading voltage in the HV Const. mode	Section 8.3.4.4
INERT	XXXX	mbar	r/s	Inert gas partial pressure	Section 8.3.5.2

(Sheet 1 of 2)

A0510COMPPRO

Name	Format	Unit	Access read/ set	Function	Description
INTERLOCK	XX or NONE	—	r	List active interlocks	Section 8.3.7.4
LEAKRATE	XXXX	mbar / 2 min	r	Halogen (fluorine) source leak rate	Section 8.3.8.3
MENU	X or RESET	—	r/s s	Number of current gas menu Reset menu to factory settings	Section 8.3.5.3
MODE	HV, EGY NGR or EGY PGR	—	r/s	Operating mode	Section 8.3.4.1
POWER STABILIZATION ACHIEVED	YES or NO	—	r	Power stabilization according to ”EGY RANGE“ reached or not	Section 8.3.7.5
PRESSURE	XXXX	mbar	r	Laser tube pressure	Section 8.3.7.6
PULSE DIFF	XXXX	pulses	r	Difference between trigger pulses and laser pulses	Section 8.3.7.7
RARE	XXXX	mbar	r/s	Rare gas partial pressure	Section 8.3.5.2
RESERVOIR TEMP	XX.X	°C	r	Laser tube pressure	Section 8.3.7.8
REPRATE	XXXX	Hz	r/s	Repetition rate of laser pulses with internal triggering	Section 8.3.4.6
ROOMTEMP	XX.X	°C	r/s	Room temperature of HCl-source	Section 8.3.8.5
TEMP	XX.X	°C	r	Temperature of fluorine source	Section 8.3.8.4
TEMP CONTROL	ON or OFF	—	r/s	Laser tube temperature control active or inactive	Section 8.3.7.9
TIMEOUT	ON or OFF	—	r/s	Time-out for RS232 active or inactive	Section 8.3.6.3
TOTALCOUNTER	XXXXX	10^3 pulses	r	Total counter reading	Section 8.3.6.1
TRIGGER	INT or EXT	—	r/s	Trigger source (internal or external)	Section 8.3.4.5
TYPE OF LASER	XXXXXX	—	r	Model of laser device	Section 8.3.9.1
VERSION	X.XX	—	r	Software version of the Communication Interface	Section 8.3.9.2

(Sheet 2 of 2)

A0510COMPPRO

8.3.2 Operating Mode Setting Restrictions

In some cases laser parameter commands will not be accepted. The table below indicates, depending on the current operating mode, if a parameter command is accepted (yes) or refused (no).

Parameter Command	Current Operating Mode (OPMODE)						
	Off	On	HI / PGR	New Fill	Manual Fill Inert	Purge <xy> Line [a]	Purge Reservoir
HV	yes[b]	yes[b]	no	no	no	no	no
EGY	yes[c]	yes[c]	no	no	no	no	no
Reprate	yes	yes	no	no	no	no	no
Mode	yes	no	no	no	no	no	no
Counter	yes	no	no	no	no	no	no

a. The limitations also apply for the command FLUSH <xy> LINE
b. Will only be accepted in the HV CONST mode
c. Will only be accepted in the EGY CONST mode

8.3.3 Parameter Polling Restrictions

In some cases, the parameter value indicated as a reply to a polling command will vary depending on the settings of other parameters. Such cases are indicated in the following table.

Current mode	Current OPMODE	HV?	EGY?
HV	Off, New Fill, Purge Reservoir, Purge / Flush <xy> Line	Set value	0
HV	On, HI / PGR	Set value	Measured value, 0, when the laser was off for at least 3 seconds
EGY NGR, EGY PGR	Off, New Fill, Purge Reservoir, Purge / Flush <xy> Line	Last applicable value	Set value
EGY NGR, EGY PGR	On, HI / PGR	Current value	Current value

A0510COMPPRO

8.3.4 Running Modes and Operating Parameters

8.3.4.1 MODE

The laser can operate in the HV CONSTant mode or EGY CONSTant mode with or without gas actions (see Section 2.7 on page 31). This command sets or calls the running mode. It is available in all operating modes when the gas handling procedures have been completed.

Syntax:

Setting:	MODE=XXXX
Polling:	MODE?
Reply:	XXXX

Syntax Description:

XXXX	Running mode	
	HV	HV Const.
	EGY PGR	EGY Const. with gas actions
	EGY NGR	EGY Const. without gas actions

8.3.4.2 EGY and EGY SET

This setting command has three functions:

– In the EGY Const mode, the EGY sets the setpoint for the stabilization of the beam energy (”preset energy“). This value is reset when the laser device is next restarted. With some lasers, the function is executed through the parameter command EGY SET.

– When EGY=0 is sent in the EGY Const mode, the energy value is set to the value that is predefined through the parameter PRESET_EGY in the menu data.

– During energy monitor calibration, the EGY command is required to input the externally displayed energy value.

The EGY command is available in the operating modes OFF and ON.

The reply to the polling command EGY? or EGY SET? also differs depending on the currently active running mode:

– OFF: setpoint for the beam energy (in mJ).

– ON: measured beam energy (in mJ). If the request is repeated before the next trigger puls, 0 will be displayed.

– ENERGY CAL: current monitor reading (without unit).

A0510COMPPRO

Syntax:

Setting:	EGY=aaa.aa or EGY SET=aaa.aa
Polling:	EGY? or EGY SET?
Reply:	aaa.aa

Syntax Description:

aaa.aa	Beam energy	
	Variable	decimal, 3 places before and 2 places after decimal point
	Unit	mJ (with energy monitor calibration without unit)
	Range	indicated through gas menu

8.3.4.3 EGY RANGE

This command sets or calls the range of tolerance for the beam energy in relation to the set values in the EGY PGR or EGY NGR mode. This parameter is necessary for the indication of ”POWER STABILIZATION ACHIEVED“. The command is only available in the OFF mode.

Syntax:

Setting:	EGY RANGE=aaa
Polling:	EGY RANGE?
Reply:	aaa

Syntax Description:

aaa	Energy tolerance	
	Variable	integer, 3 places
	Unit	%
	Range	1 to 100

A0510COMPPRO

8.3.4.4 HV

This command sets or calls the loading voltage for the HV Constant mode. The command is available in all operating modes. If the command has no purpose in the currently active mode, it will be ignored.

Syntax:

Setting:	HV=aa.a
Polling:	HV?
Reply:	aa.a

Syntax Description:

aa.a	Loading voltage	
	Variable	decimal, 2 places before and 1 place after decimal point
	Unit	kV
	Range	set through gas menu

8.3.4.5 TRIGGER

The laser can be internally or externally triggered. This command sets or calls the triggering mode. The command is available in the ON and OFF modes.

Syntax:

Setting:	TRIGGER=XXX
Polling:	TRIGGER?
Reply:	XXX

Syntax Description:

XXX	Trigger mode	
	INT	Internal trigger generator
	EXT	External trigger generator

NOTE
The internal trigger generator triggers a sequence of laser pulses without interruption. When interruptions are necessary (Burst mode), the external trigger mode has to be selected and an external trigger generator used.

8.3.4.6 REPRATE

This command sets or calls the repetition rate (rep. rate) for the internally triggered laser pulses. The command is available in the ON and OFF modes.

Syntax:

Setting:	REPRATE=aaaa
Polling:	REPRATE?
Reply:	aaaa

Syntax Description:

aaaa	Repetition rate	
	Variable	integer, 4 places
	Unit	Hz
	Range	as determined in the gas menu; with a higher loading voltage, the maximum repetition rate can be reduced

NOTE
With internal triggering active, the new repetition rate becomes immediately effective. In the external trigger mode, the new repetition rate will become effective when internal triggering is next activated.

A0510COMPPRO

8.3.4.7 COUNTS

When external triggering is active, the laser can be set to generate a preset number of laser pulses. This command enables the countdown value to be set or called. The laser will only accept external trigger pulses until the indicated amount is reached. After that the laser will stop and COUNTS will be set to zero. The command is only available in the OFF mode.

Syntax:

Setting:	COUNTS=aaaaa
Polling:	COUNTS?
Reply:	aaaaa

Syntax Description:

aaaaa	Amount of pulses	
	Variable	integer, 5 places
	Unit	pulses
	Range	0 to 65535

NOTE
The polling command COUNTS? indicates the currently set countdown counter value and not the current counter reading.

8.3.5 Gas System and Gas Supply

8.3.5.1 GAS MODE

The COMPex*Pro* can be supplied from premix gas cylinders or single gas cylinders (see Section 4.2.2 on page 76). This command sets or calls the gas mode. The command is only available in the OFF mode.

Syntax:

Setting:	GASMODE=XXXX
Polling:	GASMODE?
Reply:	XXXX

Syntax Description:

XXXX	Gas mode	
	PREMIX	Supply from premix gas cylinders
	SINGLE GASES	Supply from single gas cylinders

8.3.5.2 HALOGEN, RARE, BUFFER and INERT

The COMPex*Pro* can be supplied from up to four different gas cylinders (see Section 4.2.2 on page 76). These commands set the partial pressures for the individual gases in the currently active gas gas menu when the values are within the permitted range. The commands are only available in the OFF mode.

Syntax:

Setting:	*Gas*=aaaa (e.g. HALOGEN=aaaa)
Polling:	*Gas*? (e.g. HALOGEN?)
Reply:	aaaa

Syntax Description:

Gas	HALOGEN, RARE, BUFFER or INERT	
aaaa	Gas partial pressure	
	Variable	integer, 4 places
	Unit	mbar
	Range	indicated through gas menu

Example:

Set the halogen partial pressure to 100 mbar:

HALOGEN=100<CR>

Call the buffer partial pressure:

BUFFER?<CR>

2340<CR>

NOTE

The partial pressure for the halogen cylinder has to be approx. 20 times higher than the partial pressure of the halogen source as in the gas cylinders there is 5 % halogen in 95 % inert gas.

A0510COMPPRO

8.3.5.3 MENU

The gas menus enable imprortant settings for the operation of the COMPex*Pro* to be defined. The gas menus contain information regarding:

– Types of gases being used,

– Wavelength,

– Gas mode (see ”GAS MODE“, Section 8.3.5.1),

– Partial pressures of the gases,

– Predefined tube pressure (see also status code no. 27),

– Limits for the loading voltage (HV_{min}, HV_{max}),

– Predefined constant beam energy value

The MENU command enables the gas menu to be selected or requested or resets the values in the currently selected gas menu to the factory settings. The command is only available in the OFF mode.

Syntax:

Setting:	MENU=a MENU=RESET
Polling:	MENU?
Reply:	a,bbb,ccc

Syntax Description:

a	Gas menu number 1 to 6 Menu number 1 to 6
bbb	Wavelength of the gas menu in nm (e.g. 193)
ccc	Gas mixture of the gas menu (e.g. ArF)
RESET	Command to reset the settings in the selected gas menu back to the factory settings

Example:

Call the currently selected gas menu:

MENU?<CR>

1<CR>

Activate gas menu no. 2:

MENU=2<CR>

Reset the currently selected gas menu to the factory settings:

MENU=RESET<CR>

A0510COMPPRO

8.3.6 Pulse and Time Counters

8.3.6.1 TOTALCOUNTER

This command requests the amount of pulses (divided by 1000) during the total working lifetime of the laser. The requested counter cannot be reset. The command is only available in the OFF mode.

Syntax:

Polling:	TOTALCOUNTER?
Reply:	aaaaaa

Syntax Description:

aaaaaa	Total counter reading (10^3 pulses)

8.3.6.2 COUNTER

This command requests the current reading (divided by 1000) of the resettable counter or resets the counter to zero. The command is only available in the OFF mode.

Syntax:

Setting:	COUNTER=RESET
Polling:	COUNTER?
Reply:	aaaaaa

Syntax Description:

RESET	Reset the counter reading to zero
aaaaaa	Counter reading of the resettable counter (10^3 pulses)

A0510COMPPRO

8.3.6.3 TIMEOUT

To enable interruptions in the communication between the laser device and remote PC to be detected, the flow of data through the serial interface (RS232) can be monitored. The TIMEOUT command switches the RS232 time out function on and off. When TIMEOUT is switched on and there is no data flow through the RS232 within a period of one second, the laser will be shut down with the error code 31 (the polling command OPMODE? will produce the response OFF:31). The command is only available in the OFF mode.

NOTE
When the time out function is active, there should be continuous communication through the RS232 interface. Where necessary, program the remote PC with continuous requests to ensure that communication with the laser device is not interrupted resulting in the laser device being unexpectedly switched off.

Syntax:

Setting:	TIMEOUT=XXX
Polling:	TIMEOUT?
Reply:	XXX

Syntax Description:

XX	Condition	
	ON	active
	OFF	inactive

A0510COMPPRO

8.3.7 System Status and Maintenance

8.3.7.1 COD

This command switches the Charge On Demand function on and off. The COD function can only be switched on and off in the OFF mode. If the COD polling command is sent in the ON mode, the reply will indicate the time delay between the trigger signal and laser pulse, i.e. the capacitor loading time for each pulse.

NOTE
When operating the laser device with COD, only use repetition rates up to 50 Hz. Higher repetition rates cause missing pulses and are, therefore, set back to 50 Hz.

Syntax:

Setting:	COD=XX
Polling:	COD?
Reply:	XX aaa

Syntax Description:

XX	Condition (in OFF mode)	
	ON	active
	OFF	inactive
aaa	Delay time (in ON mode)	
	Variable	integer, 3 places
	Unit	µs
	Value	depending on laser device

Example:

Activate the COD function in the OFF mode:
COD=ON<CR>
Request the COD function status in the OFF mode:
COD?<CR>
ON<CR>
Request the time delay in the ON mode:
COD?<CR>
125<CR>

A0510COMPPRO

8.3.7.2 FILTER

This command sets and requests the amount of pulses that are required to calculate the average beam energy. When the input is outside of the permissible range, the last FILTER value is retained. When “0” is entered, the program will automatically set a filter value in relation to the repetition rate. The command is available in all modes.

Syntax:

Setting:	FILTER=aa
Polling:	FILTER?
Reply:	aa

Syntax Description:

aa	Filter value	
	Variable	integer, 2 places
	Unit	—
	Value	0 (automatic filter value), 1, 2, 4, 8, 16

8.3.7.3 FILTER CONTAMINATION

This command requests capacity of the halogen filter (in percent) and resets the capacity (after exchanging the filter). The command is available in all modes.

Syntax:

Setting:	FILTER CONTAMINATION=RESET
Polling:	FILTER CONTAMINATION?
Reply:	aaa

Syntax Description:

RESET	Reset command; sets the capacity after a filter exchange back to 100 %	
aaa	Filter filling level	
	Variable	integer, 3 places
	Unit	%
	Value	0 to 100

A0510COMPPRO

8.3.7.4 INTERLOCK

This reply to this polling command lists alls active interlocks. After the request, the interlock messages are deleted. The command is available in all modes.

Syntax:

Polling:	INTERLOCK?
Reply:	NONE XXX[,XXX,XXX]

Syntax Description:

NONE	No interlock active
XXX	Name of the interlock if more than one interlock is active, they are separated from each other by commas

8.3.7.5 POWER STABILIZATION ACHIEVED

This command requests if the preset stabilization of the beam energy has been reached. It is only available in the ON mode.

Syntax:

Polling:	POWER STABILIZATION ACHIEVED?
Reply:	XXX

Syntax Description:

XXX	Condition	
	YES	Stabilization reached
	NO	Stabilization not reached

A0510COMPPRO

8.3.7.6 PRESSURE

This command requests the current pressure in the laser tube. It is available in all modes.

Syntax:

Polling:	PRESSURE?
Reply:	aaaa

Syntax Description:

aaaa	Tube pressure	
	Variable	integer, 4 places
	Unit	mbar
	Value	specified through gas menu

8.3.7.7 PULSE DIFF

This command requests the difference between the amount of trigger pulses and the amount of laser pulses that reach the energy monitor. After the request or when the laser is sarted, the pulse difference is set to zero. Negative values indicate that there are fewer laser pulses than trigger pulses. With the laser switched on, the value can deviate from the actual value by ±1.

Syntax:

Polling:	PULSE DIFF?
Reply:	[-]aaa

Syntax Description:

aaa	Pulse difference	
	[-]	negative sign for fewer laser pulses
	Unit	pulses
	Value	current difference

A0510COMPPRO

8.3.7.8 RESERVOIR TEMP

This command requests the current temperature of the laser tube.

Syntax:

Polling:	RESERVOIR TEMP?
Reply:	aa.a

Syntax Description:

aa.a	Temperature of the laser tube	
	Variable	decimal, 2 places before and 1 place after decimal point
	Unit	°C
	Range	1 to 60

8.3.7.9 TEMP CONTROL

This command requests the status of the laser tube temperature control module.

Syntax:

Setting:	TEMP CONTROL=XXX
Polling:	TEMP CONTROL?
Reply:	XXX

Syntax Description:

XXX	Status of temperature control	
	ON	temperature control active
	OFF	temperature control inactive
	N/A	Temperature control module not available (reply only)

A0510COMPPRO

8.3.8 Halogen Source

8.3.8.1 ACCU

(Halogen source)
This command requests the current pressure of the halogen source accumulator. The reply is zero when there is no halogen source.

Syntax:

Polling:	ACCU?
Reply:	aaaa

Syntax Description:

aaaa	Pressure in halogen source accumulator	
	Variable	integer, 4 places
	Unit	mbar
	Value	current pressure

8.3.8.2 CAP.SET and CAP.LEFT

(Halogen source)
This command sets and requests the remaining volume of the halogen source. It is only available in the OFF mode.

Syntax:

Setting:	CAP.SET=aaa
Polling:	CAP.LEFT?
Reply:	aaa

Syntax Description:

CAP.SET	Command to set the halogen source capacity	
CAP.LEFT	Command to request the halogen source capacity	
aaa	Capacity of the halogen source	
	Variable	integer, 3 places
	Unit	%
	Range	0 to 120 (F_2 source) or 0 to 100 (HCl source)

NOTE
For the new capacity value to be accepted, the command ”CAP.SET=aaa“ has to follow the command ”OPMODE=CAPACITY RESET“.

A0510COMPPRO

8.3.8.3 LEAKRATE

(F_2 source)
The F_2 source leak test will be carried out during a new gas fill. After the gas has been filled, the laser selects the standby mode to check if there is a loss of gas. The LEAKRATE command requests the loss of pressure.

Syntax:

Polling:	LEAKRATE?
Reply:	aaa

Syntax Description:

aaa	Leak rate of the F_2 source	
	Variable	integer, 3 places
	Unit	mbar / 2 min
	Value	current leak rate

8.3.8.4 TEMP

(F_2 source)
This command requests the temparature of the heating element of the integrated F_2 source. If no F_2 source is connected, the reply is ”0“. The command can be sent in all modes. The current heater will, however, only be indicated in the NEW FILL mode.

Syntax:

Polling:	TEMP?
Reply:	aa.a

Syntax Description:

aa.a	Temperature of the F_2 source	
	Variable	decimal, 2 places before and 1 place after decimal point
	Unit	°C
	Value	current temperature

A0510COMPPRO

8.3.8.5 ROOMTEMP

(HCl source)
As the chemical reaction in the HCl source is temperature-dependent, the ROOMTEMP command indicates to the source the room temperature range. When the laser device is started, the parameter is set to ”HIGH“ (standard value). When no HCl source is connected, the setting will also be ”HIGH“. The command is available in al modes.

Syntax:

Setting:	ROOMTEMP=XXXX
Polling:	ROOMTEMP?
Reply:	XXXX

Syntax Description:

XXXX	Room temperature range	
	HIGH	temperature above 22 °C
	LOW	temperatur below 22 °C

8.3.9 General Information

8.3.9.1 TYPE OF LASER

This command requests the type (model) of laser device.

Syntax:

Polling:	TYPE OF LASER?
Reply:	XXXXXXX

8.3.9.2 VERSION

This command requests the version of the control software that is used by the Communication Interface.

Syntax:

Polling:	VERSION?
Reply:	VX.XX

A0510COMPPRO

9 TROUBLESHOOTING

This chapter describs the detection and rectification of faults that may occur when using the COMPex*Pro* laser device. It assumes that you are familar with the contents of this manual, particularly the safety instructions.

WARNING
Risk of serious injury and material damage!
Working procedures that shall only be performed by specially trained and authorized service personnel, represent a serious health and safety risk to untrained persons. Only perform procedures for which you have received specific training and authorization.

This possible faults are grouped in this chapter according to symptoms or the means of indication or (e.g. faults that are indicated by interlock messages or perceivable faults such as self-firing). This chapter contains the following sections:

Subject	Description
Warnings and error messages	Section 9.1 on page 294
Interlocks	Section 9.2 on page 308
Self-firing (laser fires a shot without a trigger pulse)	Section 9.3 on page 311
No trigger signal	Section 9.4 on page 311
Corrosion in gas system	Section 9.5 on page 312
Laser device does not start	Section 9.6 on page 313
Beam energy too low	Section 9.7 on page 314
Low light	Section 9.8 on page 319
Fuses	Section 9.9 on page 324

A0510COMPPRO

9.1 Warnings and Error Messages

This section describes warning and error messages sent by the communication interface. The display on the handheld keypad is different to the command sent through the serial interface to an external PC.

For quick reference, the messages are:

– listed in the following table in alphabetical order of the message sent to the external PC. A cross reference indicates the subsection in which the message is described in more detail.

– described in the following subsections in alphabetical order of the handheld keypad display. The corresponding message sent to the external PC can be taken from the following table.

Message to External PC	Handheld Keypad Message	Description
FLUSHING LEAKTEST:3	No Gas Flow	Section 9.1.17
FLUSHING LEAKTEST CONT:30	Leak! - Check Windows	Section 9.1.12
NEW FILL:3	No Gas Flow	Section 9.1.17
OFF:1	Interlock XXX	Section 9.1.11
OFF:2	Preset Energy Too High	Section 9.1.25
OFF:4	Fatal Error, Watchdog	Section 9.1.6
OFF:5	Fatal Error, LWL-Datalink	Section 9.1.5
OFF:6	Polling	Section 9.1.24
OFF:7	Energy Cal. Error	Section 9.1.2
OFF:8	New Gas Fill Needed	Section 9.1.15
OFF:9	No Vacuum	Section 9.1.18
OFF:10	Low Pressure	Section 9.1.14
OFF:11	No Capacity Left	Section 9.1.16
OFF:12	Error Temperature Measurement	Section 9.1.3
OFF:13	Fluorine Valve Not Opened	Section 9.1.7
OFF:21	Warm-up 8 min	Section 9.1.28
OFF:26	Low Light	Section 9.1.13
OFF:27	Wrong Pressure	Section 9.1.29
OFF:29	RAM Check Error	Section 9.1.26
OFF:31	Timeout	Section 9.1.27
OFF:33	Halogen Pressure Too High	Section 9.1.8
OFF:35	Not Available	Section 9.1.20
OFF:39	Inert Valve Closed	Section 9.1.10
OFF:41	OFF:41	Section 9.1.21
ON:2	Preset Energy Too High	Section 9.1.25

(Sheet 1 of 2)

A0510COMPPRO

Message to External PC	Handheld Keypad Message	Description
ON:03	Duty Cycle Exceeded	Section 9.1.1
ON:8	New Gas Fill Needed	Section 9.1.15
ON:9	No Vacuum	Section 9.1.19
ON:10	Low Pressure	Section 9.1.14
ON:13	Fluorine Valve Not Opened	Section 9.1.7
ON:34	HI In Prep	Section 9.1.9
ON:37	Warning! repetition rate for COD 50 Hz	Section 9.1.29,
ON:40	ON:40	Section 9.1.22
ON:41	ON:41	Section 9.1.23
PASSIVATION FILL:3	No Gas Flow	Section 9.1.17
PURGE RESERVOIR:3	No Gas Flow	Section 9.1.17
SAFETY FILL:3	No Gas Flow	Section 9.1.17
TRANSPORT FILL:3	No Gas Flow	Section 9.1.17
—	Fatal Error, Com-Datalink	Section 9.1.4

(Sheet 2 of 2)

NOTE
The error ”Fatal Error, Com-Datalink“ is only indicated on the handheld keypad.

9.1.1 Duty Cycle Exceeded (ON:03)

Reason:

The laser has exceeded its duty cycle (more than 12000 pulses in any 20 minutes). This warning message will not be indicated by all lasers.

Solution:

Run the laser for a period of time at a lower repetition rate.

9.1.2 Energy Cal. Error (OFF:7)

Reason:

The energy reading could not be adjusted within a range of 99-200 during the energy calibration procedure (see Section 7.7.1 on page 223).

Solution:

Insert an attentuator or remove an attentuator as described in Section 7.7.3 on page 230.

A0510COMPPRO

9.1.3 Error Temperature Measurement (OFF:12)

This is an error message relating to the fluorine source. Please refer to the fluorine source's manual for further information.

9.1.4 Fatal Error, COM-Datalink (-)

(Only displayed on the handheld keypad, not sent to the external PC) Communication between handheld keypad and communication interface is interrupted.

Reason (1):

Handheld keypad and laser device are not properly connected.

Solution:

Switch off the laser device and re-connect the handheld keypad to the laser device.

Reason (2):

Communication link damaged.

Solution:

Call COHERENT LAMBDA PHYSIK service.

9.1.5 Fatal Error, LWL-Datalink (OFF:5)

LWL is the German language abbreviation for 'Lichtwellenleiter', a Fiber Optics Light Waveguide (FOL).

Reason (1):

The FOL data ring is improperly connected.

Solution:

1. Switch off the laser device.
2. Remove the service cover.
3. Remove the cover from the communication interface
4. Remove the communication interface without disconnecting the FOLs.
5. Ensure that all FOLs are properly connected. Each FOL is marked with a code indicating the port to which it is to be connected.

A0510COMPPRO

Reason (2):

FOL data ring interrupted or a module damaged.

Solution:

1. Switch off the laser device.
2. Remove the service cover.
3. Remove the cover from the communication interface
4. Remove the communication interface without disconnecting the FOLs.
5. Ensure that all FOLs are properly connected to their ports (energy monitor, communication interface, gas handling module).
6. Check that all FOLs have a min. bending radius of 50 mm.
7. Ensure that the Communication Interface is sending a (red) light pulse.

   After switching on the 24 V power supply, the communication Interface should send a light pulse for a few seconds. To check this you will need the help of an additional person. Proceed as follows:
   - I. (1st person) Disconnect the Data Out FOL from the communication interface.
   - II. (2nd person) Switch on the 24 V power supply with the key switch.
   - III. (1st person) Watch for a light signal in the Data Out socket of the communication interface for several seconds. If there is no light, the communication interface is damaged. Call COHERENT LAMBDA PHYSIK service.
   - IV. Switch off 24 V power supply with the key switch.
   - V. Re-connect the Data Out FOL to the communication interface.
8. Ensure that the FOL data ring is closed:

   To check this you will need the help of an additional person. Proceed as follows:
   - I. (1st person) Disconnect the Data In FOL from the communication interface
   - II. (2nd person) Switch on the 24 V power supply with the key switch.
   - III. (1st person) Watch for a light signal in the Data In FOL for several seconds. If none appears, a module is damaged. Call COHERENT LAMBDA PHYSIK service.
   - IV. Switch off the 24 V power supply with the key switch.
   - V. Re-connect the Data In FOL to the communication interface.

A0510COMPPRO

9. Check for defective FOLs.

   To check this you will need the help of an additional person. Proceed as follows:

   - I. (1st person) Disconnect Data In FOL from the energy monitor.
   - II. (2nd person) Switch on the 24 V power supply with the key switch.
   - III. (1st person) Watch for a light signal in the Data In FOL for several seconds. If one appears, FOL is in order. If not, remove the FOL.
   - IV.(2nd person) Switch off 24 V power supply with the key switch.
   - V. (1st person) Disconnect Data In FOL from gas handling module.
   - VI. (2nd person) Switch on the 24 V power supply with the key switch.
   - VII. (1st person) Watch,for a light signal in the Data In FOL for several seconds. If one appears, the FOL is in order. If not, remove the FOL.
   - VIII. (2nd person) Switch off the 24 V power supply with the key switch.

   If the COMPex*Pro* has no built-in halogen source,omit steps IX to XII.

   - IX. (1st person) Disconnect Data In FOL from halogen source.
   - X. (2nd person) Switch on the 24 V power supply with the key switch.
   - XI. (1st person) Watch,for a light signal in the Data In FOL for several seconds. If one appears, the FOL is in order. If not, remove the FOL.
   - XII. (2nd person) Switch off the 24 V power supply with the key switch.

10. If all FOLs are working, one of the modules is damaged. In this case, call COHERENT LAMBDA PHYSIK service.

Reason (3):

Software is not compatible with a newly installed module.

Solution:

Call COHERENT LAMBDA PHYSIK service.

A0510COMPPRO

9.1.6 Fatal Error, Watchdog (OFF:4)

Reason:

Gas handling module does not respond.

Solution:

Switch off the laser device, wait a minute and restart. If problem remains, call COHERENT LAMBDA PHYSIK service.

9.1.7 Fluorine Valve Not Opened (OFF:13; ON:13)

This is a warning or error message relating to the fluorine source. Please refer to the fluorine source's manual for further information.

9.1.8 Halogen Pressure Too High (OFF:33)

This is an error message relating to the fluorine source. Please refer to the fluorine source's manual for further information.

9.1.9 HI in Prep (ON:34)

This is a warning message relating to the fluorine source.

Reason:

The halogen source is just preparing a halogen injection. This may last a few minutes.

Solution:

Wait a few minutes.

9.1.10 Inert Valve Closed (OFF:39)

Reason:

A manual fill of inert gas has been terminated.

This message is either a warning or an error message:

– Warning: the inert valve was open for 10 seconds and is now closed.

– Error message: the tube pressure exceeded 3800 mbar during the fill. Therefore, the fill has been terminated.

Solution:

1. Warning: No action required.
2. Error message: Reduce the tube pressure.

9.1.11 Interlock XXX (OFF:1)

Reason:

A serious malfunction has occurred (XXX" indicates the name of an interlock).

With a handheld keypad the name of the interlock is displayed.

When the laser is controlled through an external PC, the interlock can be identified using the command INTERLOCK?.

Solution:

See Section 9.2 on page 308.

9.1.12 Leak!-Check Windows (FLUSHING LEAKTEST CONT:30)

Reason:

A leak test during the flushing procedure has failed.

Solution:

Check the tube windows for leaks. After solving the problem continue by pressing <ENTER> (with external PC: send OPMODE=CONT).

A0510COMPPRO

9.1.13 Low Light (OFF:26)

The energy monitor has not detected a laser light pulse after a trigger pulse.

Reason:

At least 30% of all pulses within 10 seconds are missing.

Solution:

See Section 9.8 on page 319.

9.1.14 Low Pressure (OFF:10; ON:10)

This is a warning or error message relating to the fluorine source. Please refer to the fluorine source's manual for further information.

9.1.15 New Gas Fill Needed (OFF:8; ON:8)

This message only occurs in Energy Constant Mode. It may be either a warning or an error message:

– Warning: the charging voltage has exceeded the threshold voltage HV_{repl}.

– Error message: the charging voltage has exceeded the maximum possible voltage HV_{max}.

Reason (1):

The laser gas is of insufficient quality.

Solution:

Perform a New Fill (see Section 7.5.1 on page 192).

Reason (2):

The EGY Const. value is too low. Consequently the HV is lower than the lasing threshold.

Solution:

Increase the EGY Const. value.
If the problem remains, follow the flowchart "Beam Energy too Low" (see Section 9.7 on page 314).

A0510COMPPRO

9.1.16 No Capacity Left (OFF:11)

This is an error message relating to the halogen source. Please refer to the halogen source's manual for further information.

9.1.17 No Gas Flow (XX:3)

No gas flow has been detected in one of the gas lines. With control from an external PC, "XX" represents the name of the operating mode (OPMODE) at which the error occurred (e.g. PASSIVATION FILL, PURGE RESERVOIR etc.).

Reason (1):

Gas cylinder valve not opened.

Solution:

Open the gas cylinder valve.

Reason (2):

Incorrect pressure regulator setting.

Solution:

Set the pressure regulator to the necessary value (see Section 4.2.2 on page 76).

Reason (3):

Gas cylinder pressure too low

Solution:

Exchange the gas cylinder (see Section 7.4.3 on page 182 or Section 7.4.4 on page 187).

A0510COMPPRO

9.1.18 No Vacuum (OFF:9)

This error message is displayed after a safety fill.

NOTE
With a handheld keypad, do not confuse the warning and the error message “No Vacuum”. The warning is a function of the optional halogen source while injecting or filling the laser tube with halogen.The error only occurs after an unsuccess-ful evacuation of the laser tube.

Symptom (1):

Vacuum Pump did not run.

Reason:

Vacuum Pump defective.

Solution:

1. Switch off and secure the laser device.
2. Ensure that the vacuum pump power supply line is properly connected to the COMPex*Pro*.
3. Check the vacuum pump fuse. Replace, if necessary.
4. Visually check the vacuum pump power supply line.

Symptom (2):

Vacuum Pump continues to run.

Reason:

Laser tube has a leak.

Solution:

1. Switch off and secure the laser device.
2. Ensure that there is no leak at the tube optics. If there is a leak which cannot be sealed, call COHERENT LAMBDA PHYSIK service.
3. Perform a leak test in the gas line to the vacuum pump. If leaky, replace line.
4. Check halogen filter for leak. For this purpose check the O-rings inside the halogen filter housing for damage and replace the O-rings if necessary. Check if the butterfly nuts on the halogen filter housing are tightened (see Section 7.11.2 on page 246). If the problem remains, call COHERENT LAMBDA PHYSIK service.

9.1.19 No Vacuum (ON:9)

This is a warning message relating to the halogen source. It occurs when a predefined minimum pressure is not reached after evacuating the gas system inside the halogen source.

To solve the problem follow the instructions described in Section 9.1.18. Additionally refer to the instructions concerning this warning message in the halogen source's manual.

9.1.20 Not Available (OFF:35)

This is a warning message relating to the halogen source. It occurs when attempting to call a function which is not available when operating the COMPex*Pro* with a halogen source (e.g. when performing a partial gas replacement).

9.1.21 OFF:41 (OFF:41)

The message "OFF:41" appears on the handheld keypad as well as being sent through the serial interface to an external PC.

Reason:

In the Energy Constant Mode, the entered energy value exceeds the set value in the menu data by more than 5 %. The laser is in the OFF mode.

Solution:

Enter a lower (valid) value.

9.1.22 ON:40 (ON:40)

The message "ON:40" appears on the handheld keypad as well as being sent through the serial interface to an external PC.

Reason:

In the Energy Constant Mode, the HV is adjusted to the lowest possible value but the laser beam output energy cannot be stabilized as low as requested.

Solution:

Increase the EGY value (see Section 6.3.4 on page 163).

A0510COMPPRO

9.1.23 ON:41 (ON:41)

The message ”ON:41“ appears on the handheld keypad as well as being sent through the serial interface to an external PC.

Reason:

In the Energy Constant Mode, the entered energy value exceeds the set value in the menu data by more than 5 %. The laser is in the ON mode.

Solution:

Enter a lower (valid) value.

9.1.24 Polling (OFF:6)

Reason:

At least one module in the laser device did not respond.

Solution:

Switch off the laser device and switch on again. If the problem remains, call Lambda Physik service.

9.1.25 Preset Energy too High (OFF:2; ON:2)

This message only occurs if the running mode is an Energy Constant Mode. It may be either a warning or an error message.

– Warning: the charging voltage has exceeded the threshold voltage HV_{repl}.

– Error message: the maximum possible voltage HV_{max} has been reached.

Reason (1):

The laser gas is of insufficient quality.

Solution:

Perform a New Fill (see Section 7.5.1 on page 192).

A0510COMPPRO

Reason (2):

The EGY Const. value is too high. Consequently the HV limit has been reached.

Solution:

Reduce the EGY Const. value.
If the problem remains, follow the flowchart “Beam Energy too Low” (see Section 9.7 on page 314).

9.1.26 RAM Check Error (OFF:29)

This error message indicates incorrect menu data in the CI’s zero power RAM. The menu data can still be downloaded even in this failure scenario.

Reason:

RAM check failed. Communication interface or connections damaged.

Solution:

Call Lambda Physik service.

9.1.27 Timeout (OFF:31)

This error message appears if no data transfer has occurred through the RS232 serial interface within a period of one second.

Reason (1):

RS232 plug not properly connected.

Solution:

Check RS232 plug for proper connection.

Reason (2):

Control software failure.

Solution:

Switch the laser device off and then on again. Where necessary, program the remote PC with continuous requests to ensure that communication with the laser device through the serial interface is not interrupted.

A0510COMPPRO

Reason (3):

Communications interface damaged.

Solution:

Call Lambda Physik service.

9.1.28 Warm-up 8min (OFF:21)

Reason:

Laser device has just been started and is now warming up the thyratron.

Solution:

Wait for eight minutes.

9.1.29 Warning! Repetition Rate for COD 50 Hz (ON:37)

This warning can only occur with an active COD.

Reason:

Although COD only supports repetition rates up to 50 Hz, the preset repetition rate is more than 50 Hz; consequently, the COMPex*Pro* has set the repetition rate to 50 Hz.

Solution:

Set repetition rate to 50 Hz or less.

9.1.30 Wrong Pressure (OFF:27)

The laser tube pressure is out of range. The tube pressure must be within a range of ± 20% of the default tube pressure as specified in the Gas Menu.

Reason (1):

Pressure settings in the Gas Menu are too high or too low.

Solution

Reduce or increase settings in the gas menu so that the sum of all partial pressures does not deviate from the default pressure by more than ± 20 %

Reason (2):

Laser tube has a leak.

Solution:

Check the laser tube for leaks. If the leak cannot be sealed, call Lambda Physik service.

Reason (3):

Pressure detector on the laser tube defective.

Solution:

Call Lambda Physik service.

9.2 Interlocks

An interlock refers to an error message indicating a malfunction or critical interference. The high voltage is switched off, but the laser device remains powered up. The advantages of this method are that the entire system does not need to be restarted when there is a simple malfunction and communication with the processor is still possible.

More than one interlock can occur at a time. To receive information about the current interlocks:

1. Press the function key <F1> on the handheld keypad.
2. Press <Cursor left> or <Cursor right> to select the interlock.
3. Press <ENTER>.

WARNING
Risk of electric shock!
Storage capacitors are charged with high voltage.
Never open the laser housing while high voltage capacitors are charged.
Measurements and work on the electrical system and its equipment shall only be carried out by a skilled electrician.

The following interlocks may occur:

– Overload (see Section 9.2.1 on page 309)
– Remote (see Section 9.2.2 on page 309)
– Temp.Res. (see Section 9.2.3 on page 310)
– Ventilation (see Section 9.2.4 on page 310)

A0510COMPPRO

9.2.1 Overload

This interlock is an electronic interlock for the HV power supply. It is activated if the high voltage charging circuit does not reach the preset high voltage level.

Reason (1):

Thyratron no longer adjusted.

Solution:

Adjust the thyratron settings (see Section 7.10 on page 242).

Reason (2):

Malfunction in the HV circuit.

Solution:

Switch the laser device off and then on again. If the problem remains, call Lambda Physik service.

9.2.2 Remote

An externally connected safety switch (e.g. door switch) connected to the 4-pin remote socket (see Section 4.3.8.2 on page 95) or one of the interlocked access panels is open.

Reason (1):

Externally connected safety switch open.

Solution:

Close contact between pins 2 and 3 of the remote socket.

Reason (2):

One of the laser device service panels is open.

Solution:

Close all service panels.

A0510COMPPRO

9.2.3 Temp.Res.

This interlock is a thermal switch which is located on top of the laser tube. The switch opens if the laser tube temperature reaches 46 °C.

Reason:

There insufficient cooling water flow, no cooling water or the cooling water is too warm.

Solutions:

1. Ensure that water flow matches the specifications (see Section 4.2.4 on page 82).
2. Ensure that the water inlet temperature is within range of specifications (see Section 4.2.4 on page 82).
3. Check that the cooling water is turned on and that there is no water leak. If the problem remains, call Lambda Physik service.

9.2.4 Ventilation

The motor which drives the gas circulation fan in the laser tube is protected by this interlock.

Reason (1):

Malfunction of the gas circulation fan motor.

Solutions:

1. Ensure that the motor is electrically connected.
2. Ensure that the fan motor is not damaged. If the problem remains, call Lambda Physik service.

Reason (2):

Damaged fan or fan bearings.

Solution:

Call Lambda Physik service.

A0510COMPPRO

9.3 Self-Firing

The laser fires a light pulse without receiving a trigger pulse.

Reason (1):

(Only with COD) COD not active

Solution (2):

Switch on COD (see Section 6.4.1 on page 165).

Reason (2):

Incorrect thyratron settings.

Solution (2):

Adjust the thyratron (see Section 7.10 on page 242).

Reason (2):

Thyratron, varistor or trigger board defective.

Solution:

Call Lambda Physik service.

9.4 No Trigger Signal

This malfunction causes the error message “LOW LIGHT” (see Section 9.8 on page 319).

A0510COMPPRO

9.5 Corrosion in Gas System

Symptom:

– Insufficient gas lifetime,

– Beam specifications not reached,

– Visible corrosion at gas lines and connections.

Reason (1):

The halogen line was not purged prior to a standstill. Consequently, halogen has come in contact with ambient humidity

Solution:

Replace the corroded lines.

Reason (2):

Halogen line has been purged prior to a standstill, but the halogen gas cylinder was not sealed properly.

Solutions:

1. Check the pressure regulator in halogen line.
2. Check the valve on the halogen gas cylinder.
3. Replace the corroded lines and pressure regulators.

A0510COMPPRO

9.6 Laser Device Does Not Start

Symptom:

After turning on the laser device with the mains and the key switches, nothing happens (lamps do not light, no sound).

Reason (1):

Mains supply line not properly connected or defective.

Solution:

WARNING
Risk of electric shock!
The mains supply line (power cord) shall only be replaced by a skilled electrician or by instructed persons under the supervision and guidance of a skilled electrician and in accordance with electrical engineering rules and regulations.

Check and, if necessary, replace the mains supply line.

Reason (2):

Incorrect main supply voltage and frequency.

Solution:

Check that the laser device is set to the correct mains supply voltage and frequency.

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Reason (3):

Defective fuse(s).

Solution:

CAUTION
Risk of damaging power supply.
A blown fuse suggests a malfunction in the power supply.
Inform service whenever a fuse is replaced.

Check the fuses F1 to F6 and, if necessary, replace any defective fuses (see Section 9.9 on page 324)

Reason (4):

No line voltage.

Solution:

Check the appropriate fuses in the building.

9.7 Beam Energy Too Low

The pulse energy may be low for many different reasons. To clearly detect the source of the problem, follow the flowcharts shown on the following pages.

A0510COMPPRO

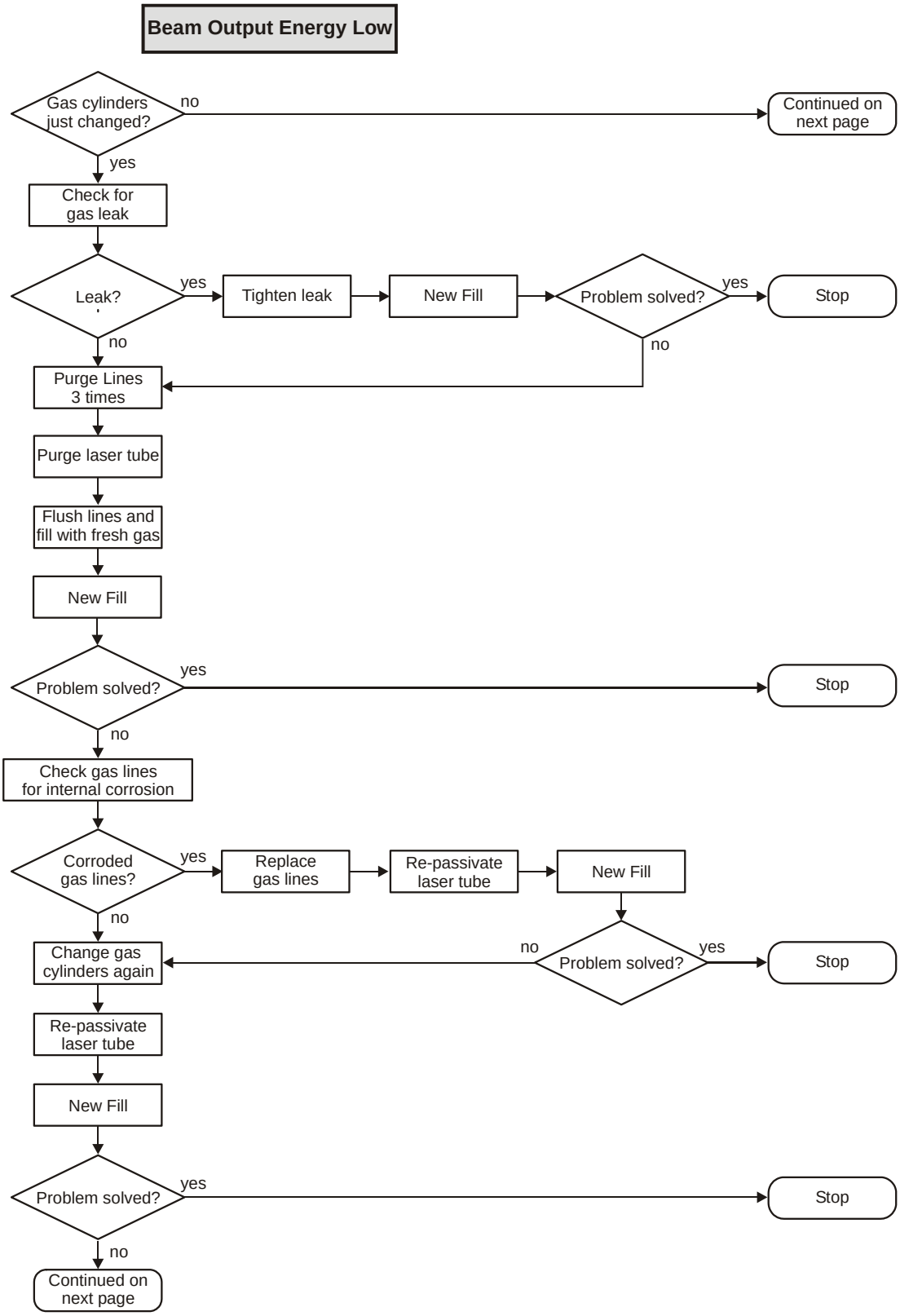

Figure 101: *Beam energy too low - part 1*

A0510COMPPRO

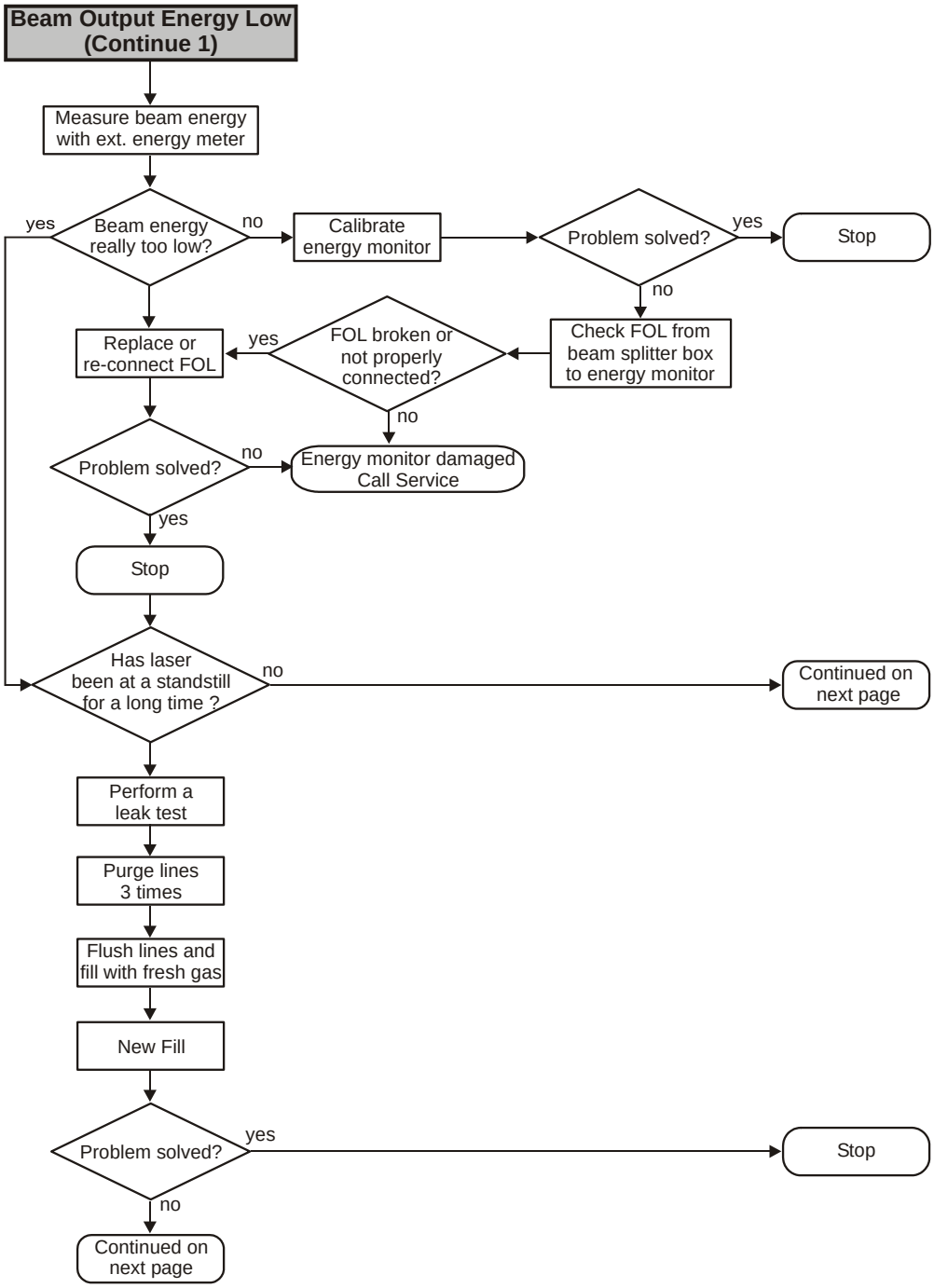

Figure 102: *Beam energy too low - part 2*

A0510COMPPRO

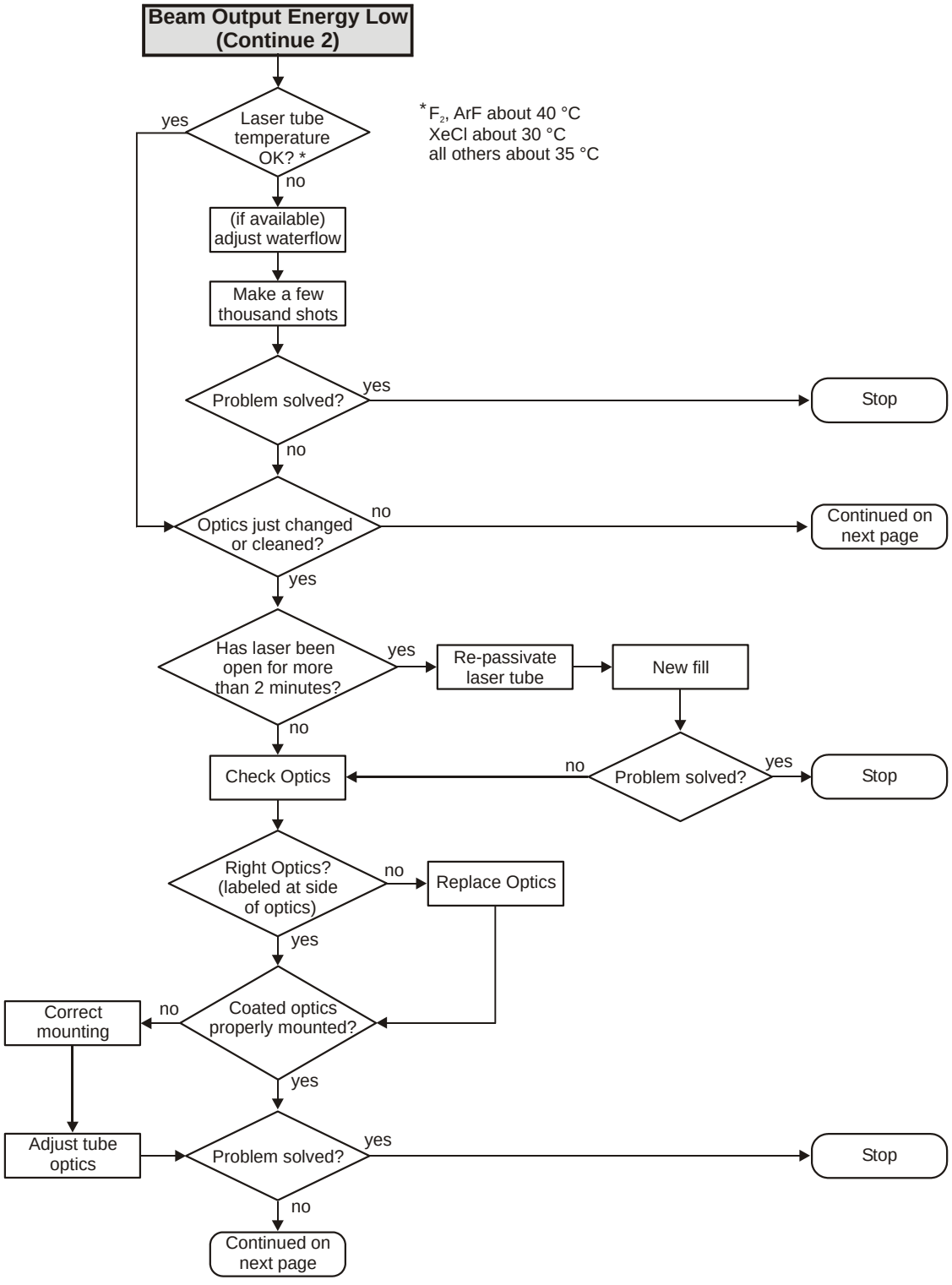

Figure 103: *Beam energy too low - part 3*

A0510COMPPRO

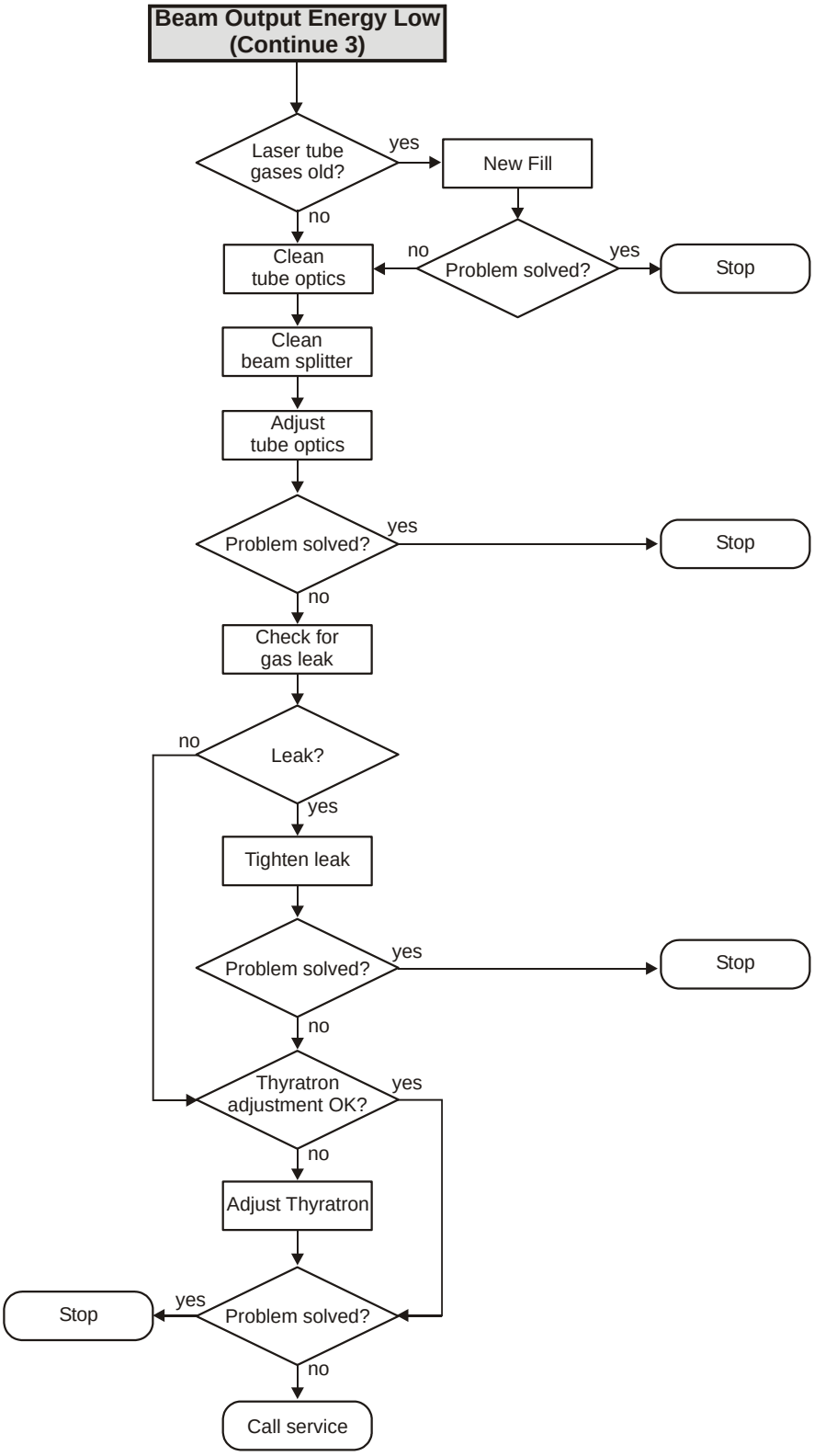

Figure 104: *Beam energy too low - part 4*

A0510COMPPRO

9.8 Low Light

The low light error my occur for several reasons. To clearly detect the source of the problem, follow the flowcharts shown on the following pages.

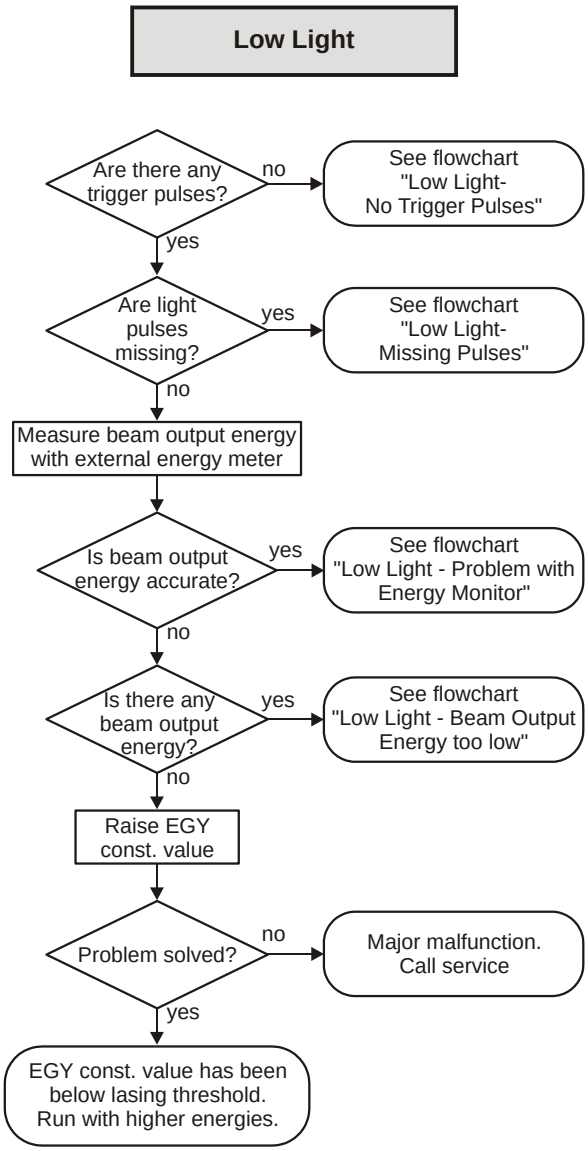

Figure 105: *Low Light*

A0510COMPPRO

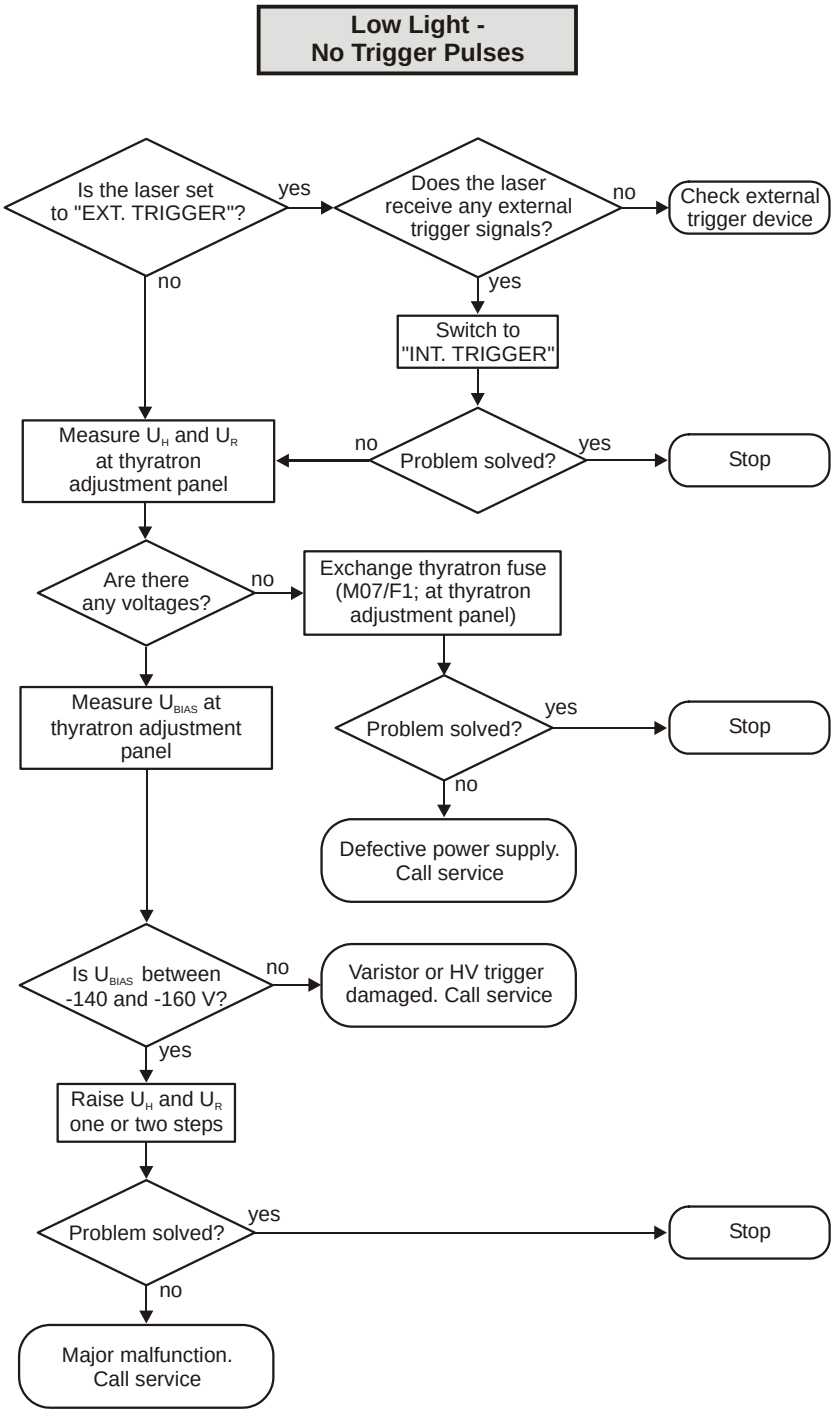

Figure 106: *Low Light - no trigger pulses*

A0510COMPPRO

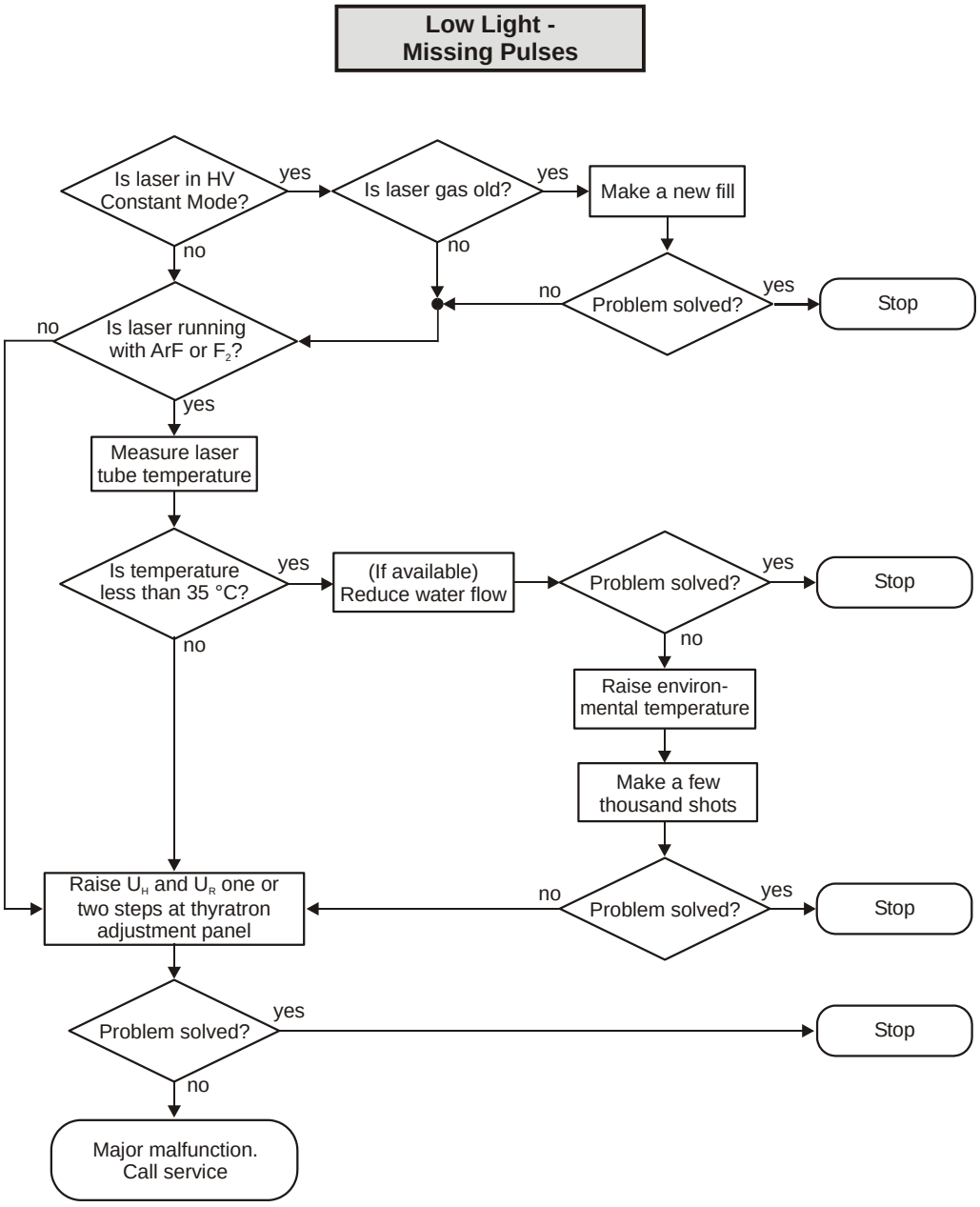

Figure 107: *Low Light - missing pulses*

A0510COMPPRO

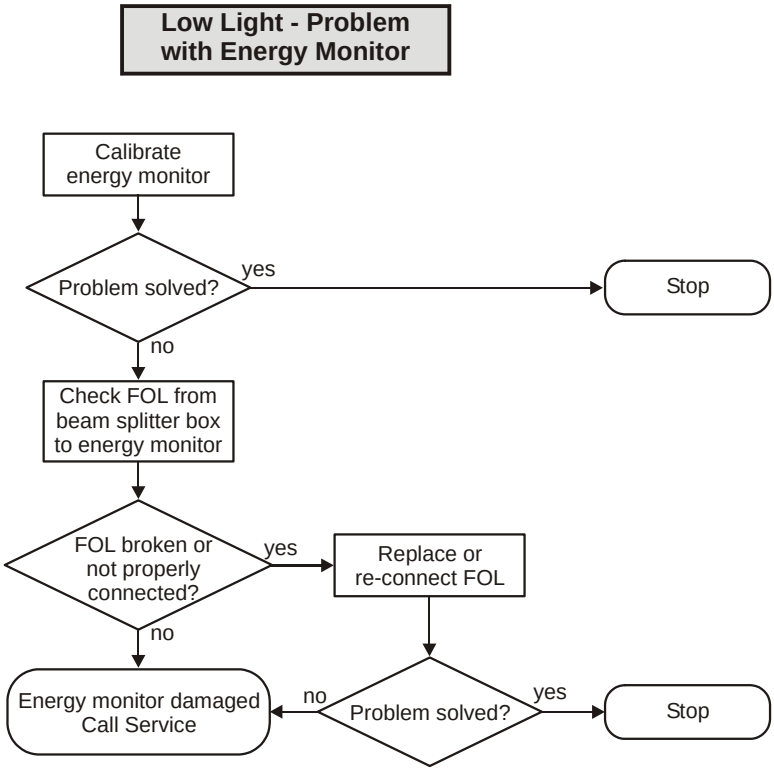

Figure 108: *Low Light - problem with energy monitor*

A0510COMPPRO

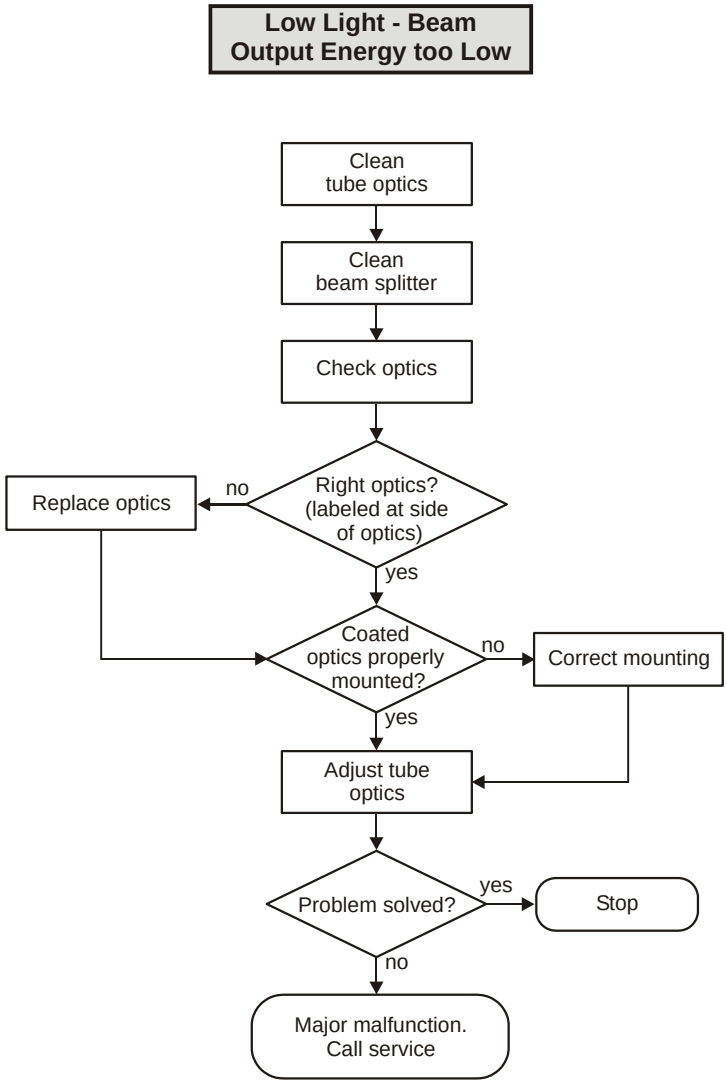

Figure 109: *Low Light - beam energy too low*

A0510COMPPRO

9.9 Fuses

9.9.1 Fuses Inside Laser Device

The fuses located inside the COMPex*Pro* are:

– at the rear side of the laser device (as seen from beam exit)

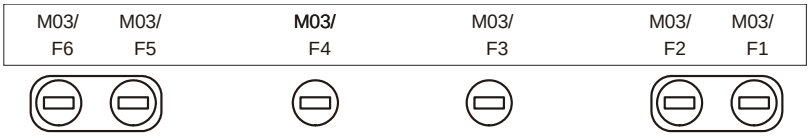

Figure 110: *Fuses at the inner rear side of COMPex*$\mathcal{Pro}$

– at the thyratron adjustment panel

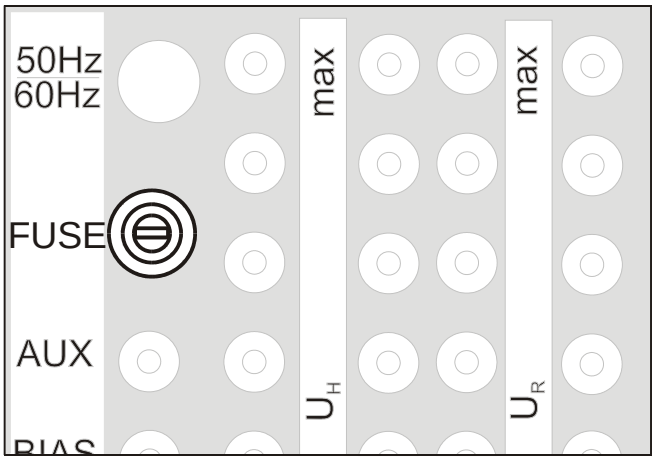

Figure 111: *Fuses at the thyratron adjustment panel*

Fuse	Value 110 V	Value 230 V	Protection
M03/F1	0.5 A slow blow	0.5 A slow blow	Fan 1 + 2
M03/F2	-	-	not used
M03/F3	8.0 A slow blow	8.0 A slow blow	Vacuum Pump
M03/F4	0.5 A slow blow	0.5 A slow blow	Servo Driver
M03/F5	2.5 A slow blow	2.5 A slow blow	Gas Circulation
M03/F6	0.063 A slow blow	0.063 A slow blow	Gas Purifier Power Supply
Thyratron	2.5 A ultra slow blow	2.5 A ultra slow blow	Thyratron Supply Module

A0510COMPPRO

9.9.2 Fuses Outside Laser Device

The fuses axccessible from the outside of the COMPex*Pro* are beside the main switch, located on the connection side.

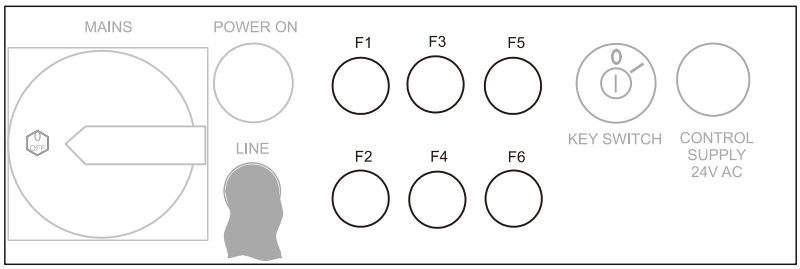

Figure 112: *Fuses at the rear outside of COMPex*$\mathcal{P}ro$

Fuse	Value 110 V	Value 230 V	Protection
F1	12.5 A slow blow	12.5 A slow blow	secondary circuit isolating transformer
F2	4.0 A slow blow	4.0 A slow blow	secondary circuit 24 V AC transformer
F3	1.0 A slow blow	0.5 A slow blow	primary circuit 24 V AC transformer
F4	1.0 A slow blow	0.5 A slow blow	primary circuit 24 V AC transformer
F5	25 A slow blow	16 A slow blow	primary circuit main line
F6	25 A slow blow	16 A slow blow	primary circuit main line

A0510COMPPRO

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10 GLOSSARY

This chapter explains laser vocabulary used throughout this manual.

Basic Module

Central module of the COMPex*Pro*. The Basic Module controls gas handling. HV power supply and tube pressure. It is controlled by the Communication Interface.

Beam Splitter

Laser optics which divide a beam into two separate beams through reflection and transmittance. In the COMPex*Pro*, a beam splitter deflects a part of the beam onto the Energy Monitor. Some beam splitters have an UV coating. This allows a minimum of beam energy loss with a maximum of reflection and transmission. Beam splitters may also act as a filter to allow transmittance of only a small range of wavelengths.

Buffer

Gas that provides optimum discharge abilities for the laser gas. Neon as a buffer is a patent of Lambda Physik (US Patent # 4,393,505).

Charging Current

Current that charges the storage capacitors in the laser.

COD

Abbreviation for Charge on Demand, an optional function of the COMPex*Pro*. With COD the trigger signal enables the power supply to charge the storage capacitors (and thus the discharge capacitors). This limits the period of time HV is applied to the thyratron. This means:

– HV is only used when needed and

– HV is not turned on without a trigger signal.

COD has been introduced to enhance components lifetime even further and to prevent self-firing. Figure 113 shows a laser triggering without COD, Figure 114 with COD.

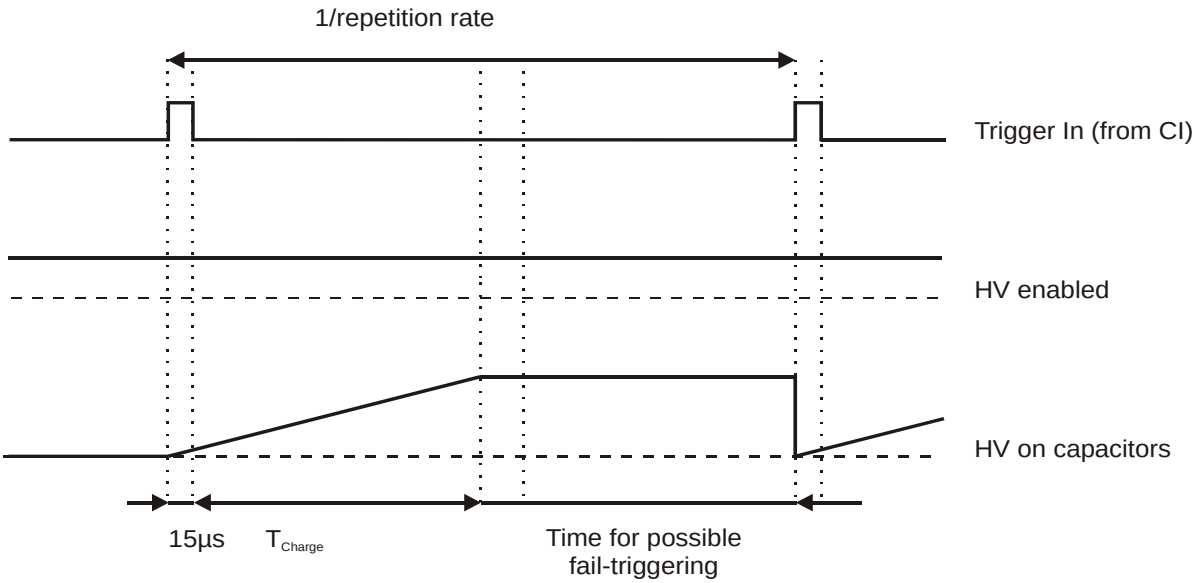

Figure 113: *Laser triggering without COD*

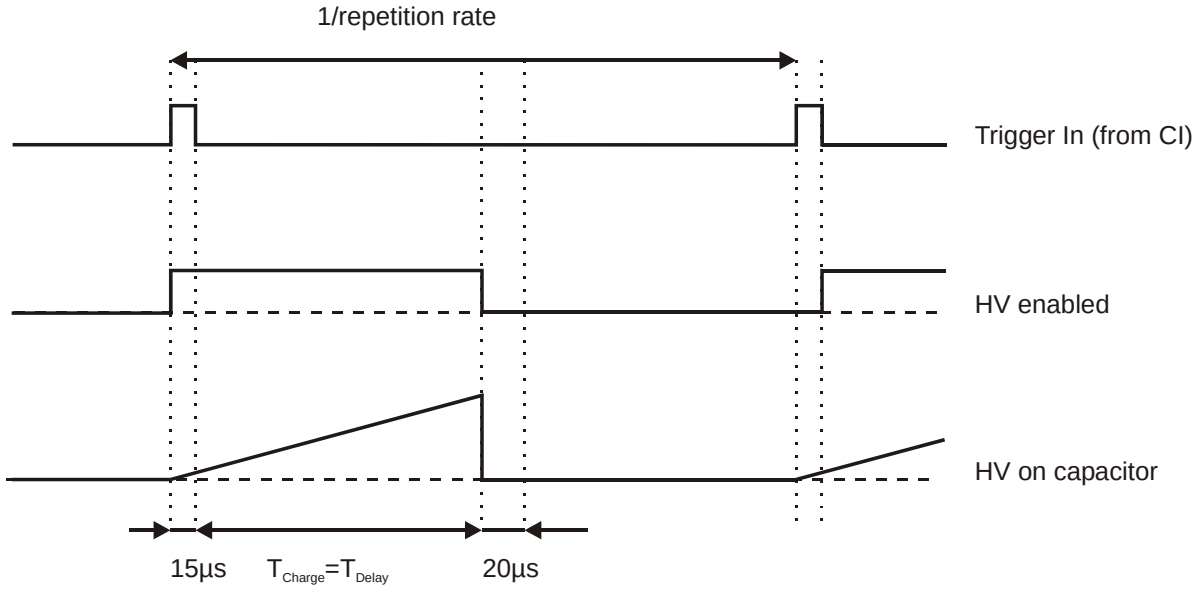

Figure 114: *Laser triggering with COD*

Communication Interface

The central control unit of the COMPex*Pro*. Contains the local and remote software for the laser. Abbreviation CI.

A0510COMPPRO

Data Ring

Module´s information link in the laser. All laser modules are connected in series and are constantly polled to watch their function. Made up of fiber optic lightwave guides (FOLs).

Discharge Capacitors

See *Peaking Capacitors*.

EGY

Abbreviation for *Energy*.

EGY CONST

Abbreviation for *Energy Constant Mode*.

Energy Constant Mode (EGY CONST)

Running Mode, that keeps the beam energy constant by continuously increasing the HV. If a given threshold HV is reached, the laser reacts with an HI or PGR or a warning, depending on the Energy Constant Mode chosen (see Section 2.7 on page 31)

Energy Monitor

Tool to measure the energy of the laser beam via a detector. Fed by a beam splitter, that reflects 10% of the beam energy onto the detector. The Energy Monitor electronics convert the light intensity into an 8-bit signal, that is evaluated by the Communication Interface.

The Energy Monitor is triggered with a FOL line from the beam splitter box to theenergy monitor electronics. If there is laser light within the beam splitter box, the FOL line leads a light pulse to the energy monitor electronics causing it to function. Thus it does not detect continuously but is triggered by the beam light itself.

Excimer Gas

Abbreviation for *Excit*ed State Di*mer Gas*.
A short-lived diatomic molecule, composed of an excited and a non-excited atom. In an Excimer laser it is created by a high voltage discharge. When decomposing, the excimer gas emits the laser radiation.

Flushing

Evacuating a gas line.

Flushing Procedure

Procedure to allow optics replacement and optics cleaning.

A0510COMPPRO

FOL

Abbreviation for Fiber Optics Light Wave Guide. Information link, that transmits via light signals. Used in excimer lasers to keep the information links free of electrical interference.
The COMPex*Pro* software sometimes uses the German language abbreviation “LWL” (for Lichtwellenleiter) is used.

FWHM

Abbreviation for Full Width Half Maximum. The width of a graph measured at 50% of the peak transmission (see Figure 115).

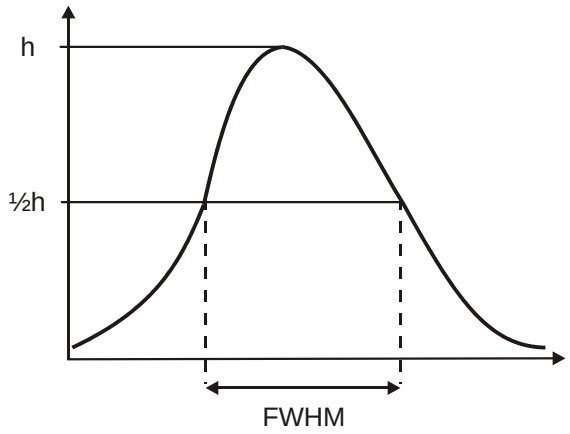

Figure 115: *Full Width Half Maximum (FWHM)*

Gas Lifetime

– Dynamic Gas Lifetime
  Lifetime of the gas in the laser tube with respect to operation. Specified as the number of pulses it takes for the beam energy to decrease from max. value (after new gas fill) to half output energy (50%). To test this the laser operates at maximum repetition rate with no interruption and max. high voltage. Neither Halogen Injections nor any other gas actions are performed.

– Static Gas Lifetime
  Lifetime of the gas in the laser tube while non-operation. Specified as the time it takes for the beam energy to decrease from maximum value (after a new gas fill) to half energy (50%). To test this, the laser operates at maximum repetition rate with no interruption and maximum possible high voltage, but only for one minute a day. Neither Halogen Injections nor any other gas actions are performed. The decline in output from one day to the next is measured.

Gas Menu

A data file in the Communication Interface. It contains information about actual and default partial pressures of the gases, allowed partial pressure ranges, default repetition rate and HV threshold settings.

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Halogen

In excimer lasers either fluorine (F) or hydrogen chloride (HCl).

Halogen Injection

Injects a single flash of halogen gas into the laser tube. Afterward the beam energy must stabilize again. Hence, there are increased pulse-to-pulse energy fluctuations for a while. Supports to increase the gas lifetime to a great extent (see Section 2.7 on page 31).

Halogen Source

The HaloSafe® halogen source is safe way to provide halogen gas. Eliminates the need for handling toxic halogen gas outside the laser device. Halogen only is provided if needed. The halogen source is available as an option.

Handheld Keypad

A keypad specially designed to make laser operations more comfortable. It provides control over all necessary laser functions.

HI

Abbreviation for *Halogen Injection*.

HV

Abbreviation for *High Voltage*.

HV Constant Mode (HV CONST)

Running Mode that keeps the charging current constant. Thus, the beam energy slowly decreases during operation until the next New Fill (see Section 2.7 on page 31).

HV_{repl}

See *Treshold Voltage*.

Inert

Gas, that does not react with any other substances. Normally helium.

Interlock

A safety feature that occurs in case of a laser malfunction, switching the laser into a safe mode (normally off). COMPex*Pro* laser devices are equipped with hardware and software interlocks. Hardware interlocks are mechanically realized by switches. Software interlocks are activated when a predefined limit value is exceeded.

Laser

Abbreviation for Light Amplification by Stimulated Emission of Radiation. According to ISO 11 145 “laser” means the lasing unit itself (see also *Laser Device*).

Laser Device

According to ISO 11 145 the “laser device” includes the laser and its supply unit (power supply, cooling supply, etc.); see also *Laser*.

Mirrors

Mirrors are the part of the laser optics, that build up the resonator. The rear mirror is a highly reflective mirror, the front mirror is translucent, thus acting as an output coupler. In most cases it has a dielectric coating depending on the operating wavelength of the laser.

New Fill

Evacuates the laser tube and refills it with fresh gases according to the settings in the Gas Menu.

NGR

Abbreviation for No Gas Replacement.

No Gas Replacement (EGY NGR)

No Gas Replacement is a laser running mode where the laser control keeps the beam energy constant. If the threshold voltage HV_{repl} is exceeded, the software reacts with a warning. If it exceeds HV_{max}, the laser is switched off and gives an error message (see Section 2.7 on page 31).

OPMODE

Abbreviation for *Operating Mode* in the Remote Software. All executable commands are called OPMODE and are executed with this command.

Partial Gas Replacement (EGY PGR)

Partial Gas Replacement is a laser running mode where the laser control keeps the beam energy constant. If the threshold voltage HV_{repl} is exceeded and a fixed number of Halogen Injections were not successful, a part of the gas in the laser tube is removed and replaced with fresh gas. Afterward, the beam energy must stabilize again. Hence, there are increased pulse-to-pulse energy fluctuations for a while (see Section 2.7 on page 31).

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Partial Pressure

In a gaseous mixture, the pressure exerted by a single component is its partial pressure. The sum of all partial pressure of the mixture equals the total pressure of the mixture.

Passivation

Process that makes the surface of the laser tube chemically inert to a halogen gas. During this process halogen gas reacts with the surface of the tube building up a layer of a halogen-metal complex. The layer is inert to one specific halogen but not to water, oxygen or other molecules. Thus it can be destroyed by humidity or other impurities that enter the tube. In this case the tube must be repassivated.

A full passivation is required when the halogen gas has been changed (chlorine to fluorine and vice versa). A full passivation can only be performed by service personnel.

Peaking capacitors

The discharge of an excimer laser is fed from discharge capacitors (“peaking capacitors”). These discrete ceramic high-voltage capacitors are coupled directly with the discharge electrodes with minimum inductance. The peaking capacitors are charged by a current pulse supplied by the storage capacitors.

PGR

Abbreviation for *Partial Gas Replacement*.

Premix

Predetermined mixture of the laser gases or its components.

Purging

Cleaning gas lines or the laser tube with inert gas.

Rare

One of the components of the excimer gas. Depending on the gas mixture it can be argon, krypton or xenon.

Repetition Rate

The number of beam pulses per second. Unit is Hz [1/s].

Reservoir

The hydrogen reservoir of the thyratron. It provides the necessary hydrogen for thyratron operation.

Resonator

The optical resonator is formed using two mirrors. The mirrors are arranged on opposite sides of the laser medium (the gas), thus providing the necessary feedback for the laser oscillator.

RS 232 C

An industry standard for serial communications connections. Adopted by the Electrical Industries Association, this Recommended Standard (RS) defines the specific lines and signal characteristics used by serial communications controllers to standardize the transmission of serial data between devices. The letter C denotes the current version of the standard.

Safety Fill

A safety feature of the COMPex*Pro*. A Safety Fill is performed if the laser tube could not be evacuated to 30 mbar (due to e.g. a Gas Leak or a defective vacuum pump). Fills the laser tube with inert gas, thus bringing it to a safe condition.

Threshold Voltage

In the Energy Constant Mode, the charging voltage is steadily increased to keep the beam energy constant. The Threshold Voltage HVrepl is a limit at which the COMPex*Pro* reacts to this increase. The reaction may be a warning (in EGY NGR), a HI (in EGY PGR) or a PGR (also EGY PGR after a number of unsuccessful HIs).

Thyratron

Fast, high voltage switch to discharge the storage capacitors as a reaction to a trigger signal (see Section 2.4.4.2 on page 20).

Trigger Pulse

A signal that causes the laser to fire a single beam pulse.

Tube Optics

Consist of resonator optics (mirrors) and windows. The COMPex*Pro* only has resonator optics.

UV

Abbreviation for *Ultraviolet Light*. The portion of the electromagnetic spectrum between 200 and 400 nm.

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VUV

Abbreviation for Vacuum Ultraviolet Light. The portion of the electromagnetic spectrum between 100 and 200 nm. At these very short wavelengths, air becomes opaque; hence, experiments must be performed in a vacuum (or inert gas).

Watchdog

A switch that alters its logical level when the reset pulses stop. All watchdogs are reset at least three times a second. If the reset fails, a breakdown is assumed. The module concerned is switched to a safe, in-active state. The Basic Module is monitored by a watchdog.

A0510COMPPRO

A0510COMPPRO

LIST OF FIGURES

Figure 1: Laser components according to ISO 11145 6
Figure 2: Laser principle 10
Figure 3: Functional design of the COMPex*Pro* 11
Figure 4: Designation of the sides of the COMPex*Pro* 12
Figure 5: Beam exit side and service side 13
Figure 6: Connection side and service side 14
Figure 7: Inside view 15
Figure 8: Cutaway drawing of the laser tube 16
Figure 9: Laser resonator and energy monitor 18
Figure 10: Layout of the high voltage circuit 19
Figure 11: Laser control system with handheld keypad 21
Figure 12: Communication interface and handheld keypadr 22
Figure 13: Laser gas supply / exhaust without halogen source . . 24
Figure 14: Laser gas supply / exhaust with fluorine source 26
Figure 15: Cooling water circuit 27
Figure 16: Pulse energy as a function of charging voltage 31
Figure 17: Voltage increase in the Energy Constant mode 31
Figure 18: Energy decrease in the HV Constant mode 32
Figure 19: Charging current with halogen injections 33
Figure 20: Charging current with Partial Gas Replacement 33
Figure 21: EGY PGR flow diagram 35
Figure 22: Charging current with No Gas Replacement (NGR) . . 36
Figure 23: EGY NGR flow diagram 36
Figure 24: Operating mode transition diagram 37
Figure 25: Laser radiation warning light and shutter 56
Figure 26: Remote connection 57
Figure 27: Key switch 60
Figure 28: Location of voltage warning lights 61
Figure 29: Labels on beam exit side 62
Figure 30: Labels on connection side 64
Figure 31: Labels inside 67

Figure 32: Dimensions COMPex*Pro* 100 Series and COMPex*Pro* F_2 Series 85
Figure 33: Dimensions COMPex*Pro* 200 Series 86
Figure 34: Beam exit position 87
Figure 35: Foot configuration 88
Figure 36: Gas connections 89
Figure 37: Position of the mains connection 92
Figure 38: Cooling water connections 93
Figure 39: Location of air intake and exhaust 94
Figure 40: Remote socket 95
Figure 41: Maintenance area of COMPex*Pro* 100 series and COMPex*Pro* F_2 98
Figure 42: Maintenance area of COMPex*Pro* 200 series 98
Figure 43: Permitted tilting gradients 102
Figure 44: Rigid transport packaging 104
Figure 45: Shock absorbing buffers 105
Figure 46: Location of clip removal tool 108
Figure 47: Removing the clips 108
Figure 48: Laser device foot 112
Figure 49: Remote socket connections 114
Figure 50: Loosen the exhaust fan outlet 118
Figure 51: Removing plug from vacuum pump 120
Figure 52: Inserting halogen filter 120
Figure 53: Adjusting the anti-torsion fork 121
Figure 54: Tightening the gas connections 124
Figure 55: Water line connections 125
Figure 56: Set of water hose connectors 126
Figure 57: Insertion of nozzle into water hose 127
Figure 58: Connecting RS232 plug to the laser device 129
Figure 59: Connecting RS232 plug to the handheld keypad . . . 129
Figure 60: Operating panel 138
Figure 61: Laser radiation warning lamp 140
Figure 62: handheld keypad 141
Figure 63: Status and parameter settings display 142
Figure 64: Closing pressure regulator 151

A0510COMPPRO

Figure 65: Opening gas cylinder valve 151
Figure 66: Setting pressure regulator to required pressure 152
Figure 67: Switching on the laser device 154
Figure 68: RUN / STOP key on the keypad 156
Figure 69: BREAK key on the keypad 157
Figure 70: Shutting down the gas supply 159
Figure 71: Main switch lockout 177
Figure 72: Removing the energy monitor 203
Figure 73: View of the optics mount with energy monitor removed 204
Figure 74: Sealing plate installed in stead of optics mount 205
Figure 75: Optics mount 205
Figure 76: Horizontal and vertical optic adjustment 207
Figure 77: Disassembled optics mount 209
Figure 78: Assembling the mirror mount 210
Figure 79: Cleaning the uncoated side of the window 213
Figure 80: Front optics with energy monitor (F_2 version) 216
Figure 81: Loosen and fasten front optics mount (F_2 Version) . . 217
Figure 82: Optic mount (F_2-Version) 218
Figure 83: Horizontal and vertical optic adjustment (F_2 version) 219
Figure 84: Position of rear optics mount (F_2 version) 220
Figure 85: Disassembled optics mount (F2 version) 222
Figure 86: View onto the beam splitter 227
Figure 87: Energy monitor bending unit (F_2 version) 229
Figure 88: Beam splitter 229
Figure 89: Energy monitor connection (F_2 version) 231
Figure 90: Direct alignment laser through laser cavity 234
Figure 91: Direct alignment laser through alignment pucks 234
Figure 92: Reflection of alignment laser on card (alignment necessary) 235
Figure 93: Reflection of alignment laser on card (optics aligned) 235
Figure 94: Setup of the unstable resonator 236
Figure 95: Marking of the optics 240

A0510COMPPRO

Figure 96: Measuring thyratron heating voltage 243
Figure 97: Measuring reservoir heating voltage 243
Figure 98: Thyratron supply voltage adjustment 244
Figure 99: Exchanging the halogen filter 248
Figure 100: Calibrating the energy monitor 269
Figure 101: Beam energy too low - part 1 315
Figure 102: Beam energy too low - part 2 316
Figure 103: Beam energy too low - part 3 317
Figure 104: Beam energy too low - part 4 318
Figure 105: Low Light 319
Figure 106: Low Light - no trigger pulses 320
Figure 107: Low Light - missing pulses 321
Figure 108: Low Light - problem with energy monitor 322
Figure 109: Low Light - beam energy too low 323
Figure 110: Fuses at the inner rear side of COMPex*Pro* 324
Figure 111: Fuses at the thyratron adjustment panel 324
Figure 112: Fuses at the rear outside of COMPex*Pro* 325
Figure 113: Laser triggering without COD 328
Figure 114: Laser triggering with COD 328
Figure 115: Full Width Half Maximum (FWHM) 330

INDEX

Numerics

24 V DC power supply 22

A

Active laser medium 9
Additional pulses 245
Adjustment range of feet 88
Air intake
  Location 94
  Specifications 83
Asbestos 51, 61

B

Basic module 57, 327
Beam dimensions 72, 73, 74
Beam divergence 72, 73, 74
Beam energy too low 314
Beam exit position 87
Beam output energy setting 163
Beam shutter 56
Beam splitter
  Cleaning 228
  Explanation 327
  Installing 228
  Location 15
  Position 18
  Purpose 18
  Removing 227
Blanks
  Use of in remote commands 257
BREAK key 143
Buffer gas 327
Buffer gas cylinder
  Exchange 187

C

Carriage Return character
  Meaning in commands 257
Charge On Demand (COD) 165, 327
Charging current 327
Charging voltage setting 164
Check valve
  Cooling system 28
CI
  see Comminication interface

Circulation fan 17
Class I laser device
Definition 44
Class IV (high power) laser device
Definition 44
Clip removal tool 107
Colon
Meaning in commands 257
Communication interface 21, 140, 328
Constructive safety features 56
Cooling water
Circuit 27
Connections 93
Specifications 82
COUNTS RESET key 146
COUNTS SEL key 146
Cursor keys
Handheld keypad 143

D

Data ring
Function 329
Selftest 29
Designated use of the laser device 40
Dimensions 84
Discharge capacitors 329
Display
Handheld keypad 142
Display elements 138
Door interlock switch
Installation 114
Door switches 30
Dynamic gas lifetimes 330

E

EGY CAL key 146
EGY key 145
EGY NGR
Flow diagram 36
Mode 162
EGY PGR
Flow diagram 35
Mode 162
Electrical connection
Location 92
Specifications 81
Electrical hazards 42
Electrical safety features 58
Emergency gas fill 171
Emergency OFF (EMO) 52
Enable key switch 139

A0510COMPPRO

Energy Constant mode 31, 150, 329
Energy efficiency 17
Energy management mode 162
Energy monitor 329
Calibration 223
Description 18
Location 15
Maintenance 223
Energy setting 163
ENTER key
Handheld keypad 143
Environmental conditions 75
Equals sign
Meaning in commands 257
Excimer
Meaning of expression 9
Excimer gas 329
Excimer laser gas lines
Preparation 130
Excimer laser gases
Turning off 159
EXE (Execute) key 143
Exhaust
Installation of line 117
Location of connection 94
Specifications 83
External laser radiation warning lamp 30
External triggering 30

F

FDA radiation performance standards 65
Fiber optics light wave guide (FOL) 330
Fire safety
Features 59
Guidelines 51
Flammable materials 51
Flow regulating valve
Cooling system 28
Flow sensor
Cooling system 28
Flush gas line procedure 179
FLUSH LINE key 148
Flushing procedure 329
Foot
Adjustment range 88
Configuration 88
Diameter 88
Full width half maximum (FWHM) 330
Function keys
Handheld keypad 147
Fuses 324

G

Gas cabinets 91
Gas connections 89
Gas cylinders
Remaining pressure 77
Safety precautions 150
Gas handling safety features 59
GAS keys 148
Gas leaks
Minimizing risk 150
Gas lifetime
Dynamic 330
Static 330
Gas lines
Connection 122
Disconnection 251
Flushing 179
Purging 180
Gas menu 330
Resetting to factory settings 167
Selection 166
Gas mixtures 76, 80
Gas protective equipment 53
Gas reservoir 17
Gas solenoid valves 25
Gas supply lines
Securing 178
Gas system
Corrosion 312
Gases
Properties of compressed gases 53
Safe working practices 53
Turning off 159
Turning on 150
General safety features 60

H

Halogen 122, 331
Physical hazards 47
Halogen filter 99
Cartridge exchange 246
Maintenance 245
Purpose 25
Halogen gas cylinders
Exchange 182
Handling 53
Halogen gases 47
Halogen injection (HI) 32, 33, 331
Manual HI 195
Halogen source 331
Handheld keypad 128, 140, 331
Hazard warning labels 61

A0510COMPPRO

Hazardous energy sources 176
Head valve
  Gas system 25
Heating voltage
  Thyratron 20
Helium 122
HI/PGR algorithm 34
High reflecting (HR) mirror 18
High voltage / electric energy
  Physical hazards 46
  Safety guidelines 52
High voltage circuit 19
High-voltage discharge 17
HV Constant mode 32
  Selection 162
HV key 145
HV power supply module 20

I

Inert gas 331
Inert gas cylinder
  Exchange 187
Information separator
  Use of in remote commands 257
Installation 101
  Exhaust lines 117
  Floor loads 103
  Gas lines 122
  Handheld keypad 128
  Laser device 101
  Laser tube exhaust line 119
  Mains power supply line 116
  Remote PC 130
  Remote socket 114
  Vacuum pump 116
  Water lines 125
Interlock 29, 331
  Overload 309
  Remote 309
  Temp.Res. 310
  Ventilation 310
Internal triggering 30
Ionizing radiation
  Radiation limit 46

K

Key switch 60, 139

L

Labels 61

Laser
Definition 6
Start 155
Stop 157
Laser assembly
Definition 6
Laser control system 21
Laser device
Does not start 313
Installation 101
Maintenance area 98
Power consumption 115
Shut down 158
Start-up 153
Transport and lifting with rigid packaging 106
Transport and lifting without rigid packaging 109
Laser gas lines
Preparation 130
Laser gases
New fill 192
Turning off 159
Laser light
Characteristics 10
Laser Logbook 173
Laser parameters 272
Laser radiation
Physical hazards 45
Safety guidelines 49
Warning lamp 140
Laser resonator
Alignment 232
Configuration 18
Laser safety classification 3
Laser Safety Officer 41, 49
Laser tube 16
Laser tube exhaust line
Installation 119
Laser unit
Definition 6
Use of protective eyewear 155
Laser warning lamp
Installation 114
LCD-display 142
Leak test (gas line)
Overpressure leak tightness 190
Vacuum leak tightness 189
Leaks 54
Light amplification 10
Lockout / tagout
Procedure 176
Requirements of lockout / tagout device 176
Low beam energy 244
Low light error 319
Low light function 268

A0510COMPPRO

M

Main switch 138
Lockout 177
Maintenance
Tube optics 200
Maintenance area 98
Maintenance schedule 174
Manual halogen injection 195
Meaning of expression
Start laser 6
Start laser device 6
Mechanical safety features 60
MENU RESET key 146
MENU SEL key 146
Missing parts 106
Missing pulses 244
MODE key 145

N

Name
Definition of name in descriptions 257
New fill 150, 192, 332
NEW FILL key 148, 193
NEW FILL mode 38
Nitrogen 28
No Gas Replacement (NGR) mode 36
No trigger signal 244, 311
NovaTube
Functional description 16
Numerical input keys
Handheld keypad 143

O

OFF mode 37
OFF, WAIT mode 38
ON mode 38
Operating elements 138
Operating modes
OPMODE=CAPACITY RESET 268
OPMODE=CONT 265
OPMODE=ENERGY CAL 269
OPMODE=FLUSH LINE 267
OPMODE=FLUSHING 265
OPMODE=HI 266
OPMODE=LL OFF 268
OPMODE=MANUAL FILL INERT 266
OPMODE=NEW FILL 262
OPMODE=OFF 260
OPMODE=ON 261
OPMODE=PASSIVATION FILL 263

A0510COMPPRO

OPMODE=PGR 266
OPMODE=PURGE LINE 267
OPMODE=PURGE RESERVOIR 263
OPMODE=SAFETY FILL 264
OPMODE=SKIP 262
OPMODE=TRANSPORT FILL 264
Setting restrictions 259, 274
Software 258
Transition diagram 37
Operating panel 138
Operating sequences 148
Operating temperature
Laser tube 17
OPMODE
Definition 332
Optic cleaning 212
Optical safety guidelines 50
Output coupler 18
Output energy setting 163
OVERLOAD message 245
Ozone 28, 48
Physical hazards 48
Protection against 54

P

Parameter commands 272
ACCU 289
BUFFER 280
CAP.LEFT 289
CAP.SET 289
COD 284
COUNTER 282
COUNTS 279
EGY 276
EGY RANGE 276
FILTER 285
FILTER CONTAMINATION 285
GASMODE 279
HALOGEN 280
HV 277
INERT 280
INTERLOCK 286
LEAKRATE 290
MENU 281
MODE 275
POWER STABILIZATION ACHIEVED 286
PRESSURE 287
PULSE DIFF 287
RARE 280
REPRATE 278
RESERVOIR TEMP 288
ROOMTEMP 291

A0510COMPPRO

TEMP 290
TEMP CONTROL 288
TIMEOUT 283
TOTALCOUNTER 282
TRIGGER 277
TYPE OF LASER 291
VERSION 291
Parameter polling restrictions 274
Partial gas replacement 33, 332
Partial pressure 333
Passivation 17, 333
Peaking capacitors 19, 333
Periodic maintenance schedule 174
Personal Protective Equipment (PPE) 41
Protective eyewear 49
Protective gloves 54
Personnel
Selection and qualification 42
PGR mode 32
Plane-parallel resonator 18
Polling commands
Description 256
Power ON lamp 139
PR mirror 18
Preionization 17
PRESET ENERGY TOO HIGH 163
Pressure regulator
Operation 131
Requirements 91
Pressure relief valve
Gas system 25
Pressure sensor
Gas system 25
Pressure switch
Purge gas system 28
Pressure vessel
Safety features 59
Safety precautions 55
Protective eyewear 49, 63, 155
Pulse duration 72, 73
Pulse energy 31, 72, 73, 74
Purge gas
Purpose 28
Supply system 28
Turning off 159
Purge gas lines 180
Purge laser tube 196
PURGE LINE key 148
PURGE RESERVOIR key 148, 196

Q

Question mark
Meaning in commands 257

R

Radiation safety features 56
Radiation warning lamp 140
Rare gas cylinder
Exchange 187
Remote interlock switches 30
Connection 114
Remote PC
Connection 130
Remote software
Parameter commands 272
Re-passivate laser tube 17, 198
Repetition rate 9, 72, 73, 74, 333
Setting 161
REPRATE key 145
Residual energy
Dissipation 177
Resonator
Alignment procedure 232
Configuration 18
Function 334
Restoring laser device to service
After lockout / tagout 178
RS232 interface 334
RUN STOP key 144
Running modes
Energy Constant mode 31
HV Constant mode 32
Selection 162

S

Safety
Organizational measures 41
Safety chain to secure working area 52
Safety compliance 39
Safety information 4
Safety symbols in this manual 5
Safety-relevant labels 61
Safety labels
Checking 113
Seismic anchorage 60
Seismic protection 55
Self-firing 311
Serial interface 95
Setting
Definition of setting in descriptions 257

A0510COMPPRO

Setting commands
Description 256
SHOCKWATCH® indicators
Purpose 106
Shut down laser device 158
Signal words
Usage in manual 4
Skin safety guidelines 51
Software
Operating modes (OPMODEs) 258
Software version 255
Solenoid valve
Gas system 23
Special characters
Use of in commands 257
Specific safety aspects 44
Start-up laser device 153
Static gas lifetime 330
Status codes 270
Output and display 38
Stimulated emission 10
Stop laser 157
Storage capacitors 19, 20
Symbols in this manual 5

T

Temperature control function 168
Temperature sensor
Cooling system 28
Temporal mode 9
Threshold voltage 334
Thyratron 334
Description 20
Heating voltages 20, 243
Location of adjustment panel 15
Maintenance 242
Total counter
Reading 169
Toxic gases
Safe working practices 53
Toxic hazards 40, 42, 53
Trademarks 3
Transport packaging
Dimensions 103
Removal 107
Remove rigid packaging 107
Removing the inner covers 110
Weight 103
Transportation fill 171, 250
TRIGGER INT EXT key 144
Trigger pulse 334
Trigger signal ports 96

A0510COMPPRO

Triggering modes 30
Changing 160
Troubleshooting
Fuses 324
Interlocks 308
Warnings and error messages 294
Turn off gases 159
Turn on gases 150
Typographic conventions in this manual 2

U

Ultra-violet light
Physical hazards 45
Safety guidelines 49
Unstable resonator
Adapter 241
Adjustment 241
Description 236
User counter
Reading 170
Resetting 170
User interface
Laser control system 21

V

Vacuum pump 99
Connection 116
Purpose 25
Vacuum valve 25
Ventilating systems 54
Visible alignment laser 234

W

Warm-up phase 154
Warning and error messages 294
Duty Cycle Exceeded 295
Energy Cal. Error 295
Error Temperature Measurement 296
Fatal Error, COM-Datalink 296
Fatal Error, LWL-Datalink 296
Fatal Error, Watchdog 299
Fluorine Valve Not Opened 299
Halogen Pressure Too High 299
HI in Prep 299
Inert Valve Closed 300
Interlock XXX 300
Leak!-Check Windows 300
Low Light 301
Low Pressure 301
New Gas Fill Needed 301

A0510COMPPRO

No Capacity Left 302
No Gas Flow 302
No Vacuum 303, 304
Not Available 304
OFF:41 304
ON:40 304
ON:41 305
Polling 305
Preset Energy too High 305
RAM Check Error 306
Timeout 306
Warm-up 8min 307
Wrong Pressure 307
Warning lights 61
Watchdog 29, 335
Water cooling 27
Water lines
Connection 125
Preparing water hoses 127
Wavelengths of excimer lasers 9
Weight 84

X

X character in descriptions 257

A0510COMPPRO

A0510COMPPRO